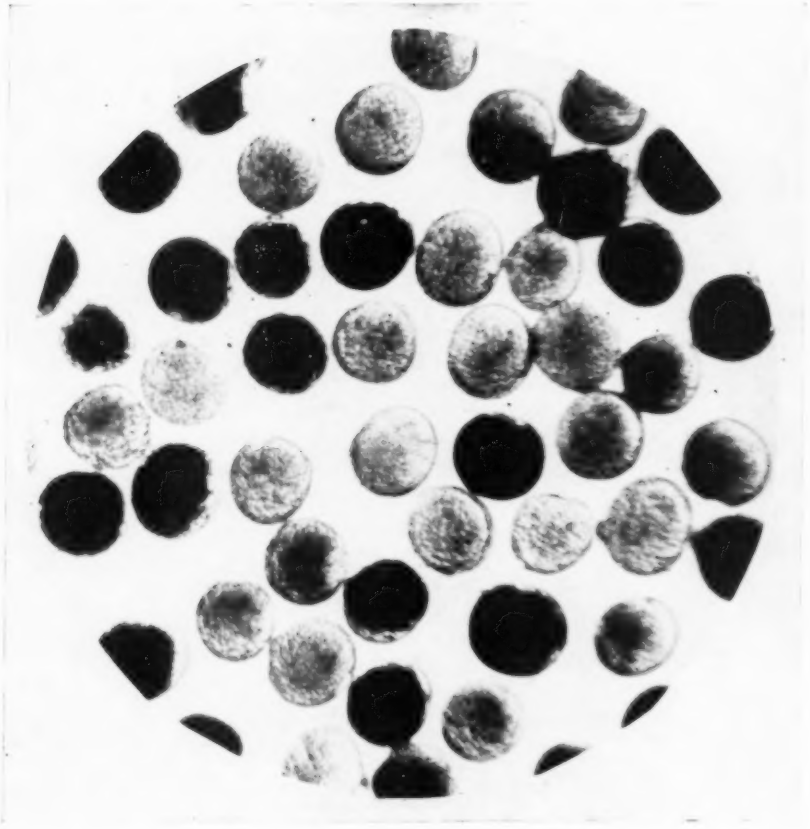
The Journal of HEREDITY



"WAXY" AND "STARCHY" POLLEN GRAINS

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Turtle Hybrids — *Chromosomes of Spiderwort*

Fused Fingers Inherited — *Sex—Gene or Hormone?*

Rapid-Growing Hybrids For New Forests

VOLUME 24 JUNE, 1933 NUMBER 6

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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The

Journal of Heredity

Vol. XXIV JUNE, 1933 No. 6

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COMING

Sex Determination Again

When the newspapers, at the time of the Sixth International Genetics Congress blossomed forth with enthusiastic announcements of a successful method of sex-determination, those who attended the Congress were even more puzzled than those who had not been there. A discussion of this incident, and of the other scanty data and experiments on which the claims were based, will be of great interest to *Journal* readers.

Endocrine Treatment as a "Gene Tester"

The breeder's problem is to separate the "carriers" which look exactly like true breeding individuals but which differ in their progeny. Endocrine injections bring to light certain recessive genes in the fowl, which fact greatly simplifies the breeder's problem. This interesting situation and other interactions of certain color-genes will be described in an early number.

Wheat-Couch Grass Hybrids

Hybrids between different genera are always matters of interest, but *fertile* genus hybrids are "news" indeed.

The JOURNAL OF HEREDITY is published monthly by the AMERICAN GENETIC ASSOCIATION, at 1918-1932 Harford Avenue, Baltimore, Md., and Victor Building, Washington, D. C. Address all communications regarding editorial matters and the business management of the Association to Room 510 Victor Building, Washington, D. C. Entered as second-class matter February 24, 1923, at the postoffice at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized December 30, 1918. Contents copyrighted 1933 by the American Genetic Association. Unauthorized reproduction of material from THE JOURNAL not permitted. The title "Journal of Heredtiy" is registered as a trade-mark in the U. S. Patent Office.

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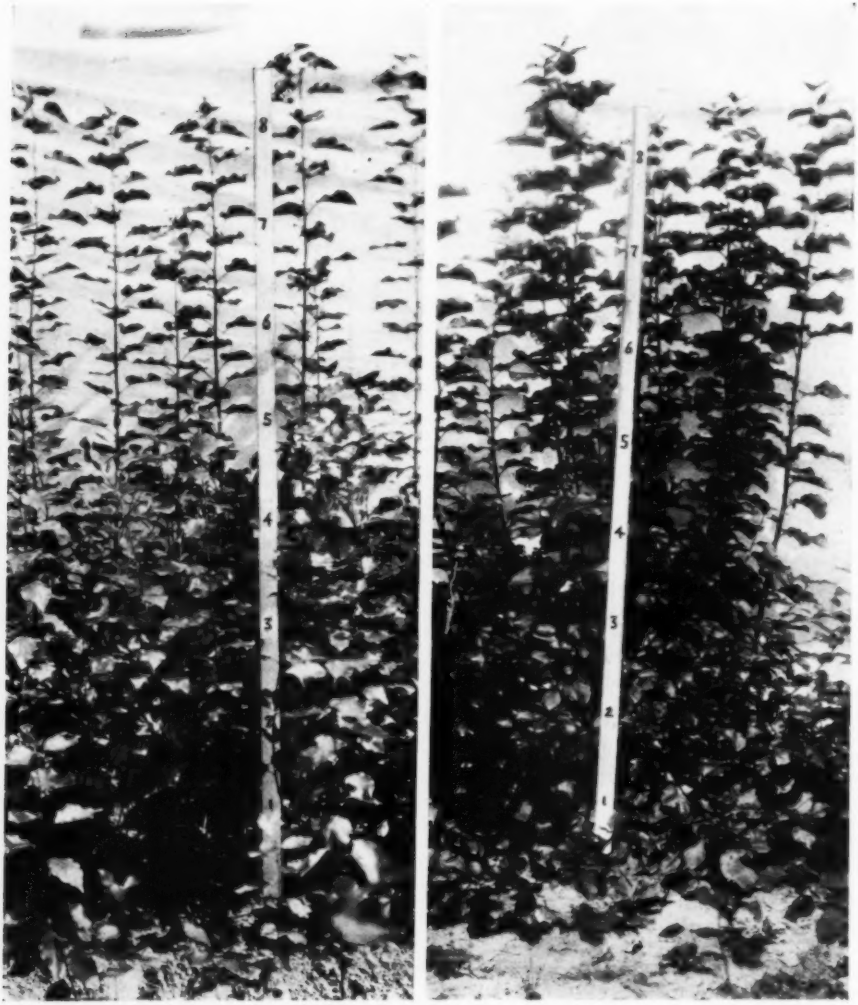


SELECTED POPLAR HYBRIDS

Frontispiece

Nursery stock of selection hybrids in Oxford Nursery at Frye, Maine. These cuttings are two years old, but growth was cut to ground in late autumn and the growth showing here, nearly nine feet, was made in one summer. *At left*, hybrid of *P. nigra* × *P. laurifolia; at right*, hybrid of *P. nigra betulifolia* × *P. trichocarpa*. Some of the latter hybrids were injured by frost in Maine.

If reforestation projects are to be an economic success it is necessary to have varieties of forest trees that grow rapidly and that are easily propagated. Certain species of poplars are desirable in some respects but have disadvantages in others. By hybridization it has been possible to combine these desirable characteristics, and by propagation from cuttings the hybrid vigor of the first generation hybrids may be utilized. Certain of the hybrids produced in these experiments combine many desirable qualities not found in any single poplar species or clon heretofore known. Their wood appears to be equal to that of other poplars for pulpwood, cheap lumber, and other purposes for which poplar wood is in demand.

RESULTS OF A PROJECT IN HYBRIDIZING POPLARS

A. B. Stout, *New York Botanical Garden*
and
E. J. Schreiner, *Oxford Paper Company*

POPLARS give promise of value in reforestation for the production of pulpwood and cheap wood for various uses chiefly because of their possibilities for rapid growth and ready propagation by cuttings. In considering definite plans for the use of poplars for reforestation it was the aim of the writers to evaluate and test the known species and hybrids and to produce through hybridization more valuable types than those already in existence.

The Wild Species of Poplars

Early in this study it became evident that the common aspens (*Populus tremuloides* and *P. grandidentata*), which supply practically all the poplar wood in the New England States, root very poorly from cuttings and grow so slowly that they are not promising for use in reforestation plantings. The northern balsam poplar (*P. tacamahacca*) seems somewhat adapted to culture in lowlands but tests showed that it does not root well from cuttings, and its rate of growth is not exceptionally rapid. The wild necklace poplar (*P. balsamifera virginiana*) and the western balsam poplar (*P. trichocarpa*) are perhaps most rapid in growth of the American wild species of poplars but they root rather poorly and *P. balsamifera virginiana* is attacked by a rust. An Asiatic species *P. Maximowiczii* is of considerable promise but appears not to be fully hardy in Maine at least as a young tree, and it also roots rather poorly from cuttings. Thus, for one reason or another, none of the wild poplars fully satisfies the demands for direct use in reforestation projects.

Earlier Poplar Hybrids

A considerable number of hybrid poplars was in existence previous to 1924, and some of these had been cultivated on a large scale especially in Europe.[8] These hybrids and also certain seedlings of various species have been propagated by cuttings, a method which leads to the establishment of clons. In considering the identity and the names of the various cultivated poplars one must be prepared to view some of the so-called species as hybrids or variants of true species that are propagated as clons.

The hybrid clon Eugenei, said to be a chance cross between a female tree of the Regenerata poplar (which may also be a hybrid) and a male Lombardy poplar, has been cultivated both in America and Europe chiefly because of its vigorous growth. *"P. angulata"* Alton, which may be a hybrid or merely a clonal variant of the American Necklace poplar, has been cultivated to some extent in Europe. The hybrid known as *"P. Serotina"* Hartig, also called the "Black Italian Poplar" and the "Peuplier Suisse," is said to be the poplar most planted in England.[2] This is a male clon that originated as a hybrid about 1700 from parents not definitely known but which may have been *P. balsamifera* var. *virginiana* and *P. nigra*. Two other hybrids of the cottonwood and black poplar group which have been quite generally cultivated as clons are *"P. regenerata"* and *"P. robusta."* Henry[2] considers that the Robusta Poplar is a stray hybrid between *"P. angulata"* and a fastigiate form of *P. nigra betulifolia* but G. Vill[10] gives the parents of this hybrid as *P. angulata* and Eugenei. Vill points out that a number of sister seedlings were originally obtained in the hybridization, which it seems was incidental, and that, at least at first, two clons were propagated under the name

RUST-SUSCEPTIBLE HYBRIDS

Figure 1

At left, hybrid of *P. balsamifera virginiana* × *P. trichocarpa. At right,* hybrid of *P. angulata* × *P. trichocarpa.* Nursery stock from roots two years old. These hybrids were vigorous until severely attacked by rust. The leaves become covered with rust pustules and then dry up and fall prematurely.

Robusta. Henry[1] grew four hybrid sister seedlings obtained from controlled pollination of *P. angulata* with pollen of *P. trichocarpa* and at least one of these was propagated under the specific name of *P. generosa.* Others have designated as new species clons which were either hybrids or varients of known species.

Some of the hybrid poplars cultivated in the United States are referred to under various common names of which

the most frequent are the "Norway Poplar," the "Sudden Sawlog Poplar," "Russian Poplar," and "Carolina Poplar." At least two different large-leaved hybrid poplars with the black poplar and cottonwood characters are grown rather widely and extensively as shade trees in the New England States. At Rumford, Maine, there are many poplars thriving as street trees on upland as well as on lowland locations. Two of these trees which were cut for study and for a pulping test had grown to a diameter (breast high) of 17 inches in 17 years and their trunks scaled 0.91 cords of pulpwood. Such growth is not unusual for hybrid poplars planted as shade trees over a considerable area of the United States.

The studies made by the junior author of this paper (and as yet unpublished) of the woods of various rapid-growing poplars show that they contain no more air space per unit area of cross-section than does the wood of the slow-growing aspens. It also appears that the hybrids of rapid growth, such as Eugenei, Norway Poplar, Robusta, and Regenerata, yield somewhat longer fibers than do the wild poplars *P. tremuloides* and *P. tacamahacca*. In weight of wood and yield of pulp per unit of volume these rapid-growing hybrids are highly satisfactory in comparison with the wood of wild species of *Populus*.

The Diseases of Poplars

Poplars are subject to various diseases some of which cause considerable injury. A rust fungus (*Melampsora medusae*) attacks nursery stock and does much damage especially to the hybrids Eugenei, Generosa, and Regenerata. In fact, these hybrids suffer so severely from rust that it now seems necessary to discontinue their propagation and use in Maine. Certain canker diseases, particularly the one caused by the fungus *Valsa sordida*, are injurious to wild aspens, to the European black poplar, to the wild necklace poplar, and to many of their hybrids.[5, 6] Nearly everywhere in America the Lombardy poplar (*P. nigra* var. *Italica*) suffers severely from diseases especially when the trees become aged and when they are grown under unfavorable conditions. *Dothichiza populea* is said to be the cause of extensive losses in forest plantations with cottonwood and black poplar hybrids in Ohio.

Thus a survey of the known poplars seems fully to support the view that any reforestation project with poplars should be directed to the use of hybrids, and that an extensive program in the hybridization of poplars is justified in the effort to produce hybrids more valuable than any already known in respect to rapidity of growth and resistance to disease.

The Results of the Breeding Work

The breeding of poplars was vigorously prosecuted by the authors of this paper during the years 1925 and 1926 and some hybridizing was also done in 1927, a preliminary report of which was published.[9] A total of about 13,000 seedlings was obtained from about 100 different cross-combinations between different types of poplars including species, varieties, and hybrids propagated as clons.

Considerable study was directed by the writers to the identity of the various trees involved in the breeding and to the matter of the proper nomenclature for them but no attempt will here be made to revise or critically to evaluate the names already in use or to survey the literature relating to poplars. It may be noted, however, that various of the known hybrids propagated vegetatively as clons masquerade as species under such names as *"Populus serotina," "P. regenerata," "P. Eugenei," "P. robusta"* and *"P. generosa,"* and also that even the old cultivated clon Balm of Gilead is much confused in the literature because it has frequently been considered as a true species (see Stout[7]) instead of as a

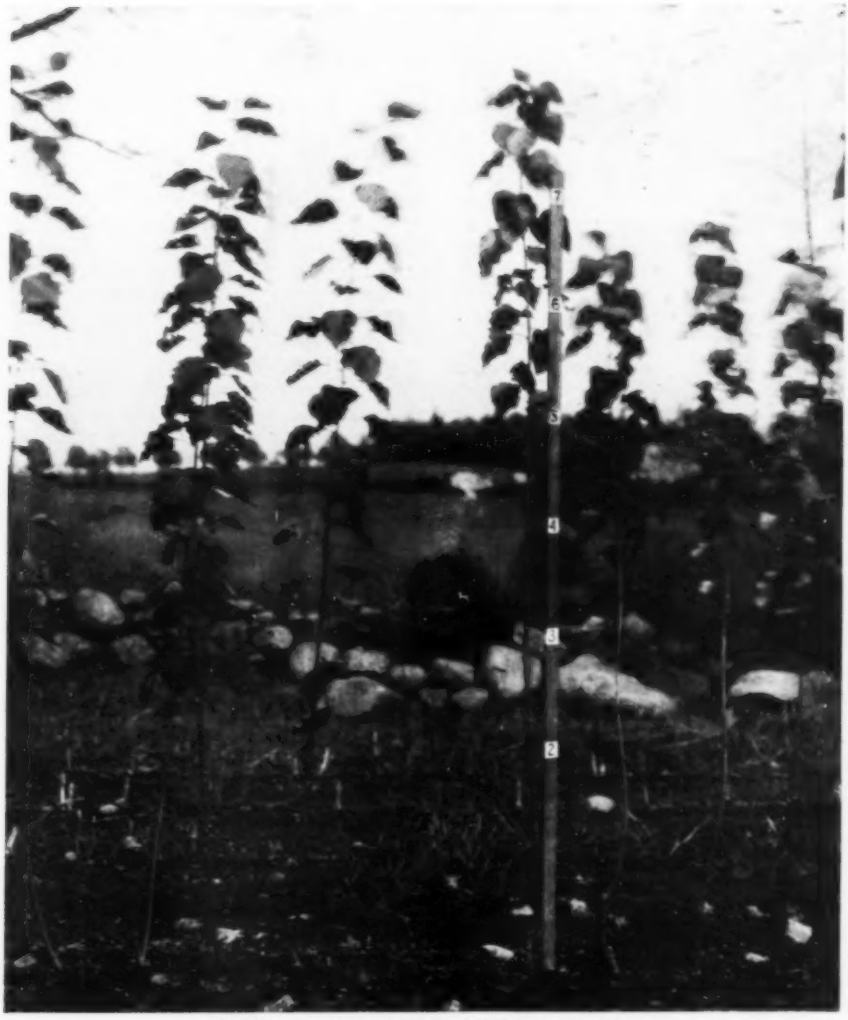
BALSAM POPLAR HYBRIDS

Figure 2

Three hybrids of *P. Maximowiczii* × *P. berolinensis* in Oxford Nursery at Frye, Maine. One year's growth of nursery stock on two-year-old roots with one-year-old stock between. These hybrids are free from rust and especially vigorous but continue growth until freezing temperatures occur when some of them suffer injury at the tips of the branches. The season's growth in Maine is as much as 10 feet. Perhaps in the longer growing season farther south the growth would be still greater.

clon of the species *P. tacamahacca*. The poplars known as *P. berolinensis, P. Petrowiskyana, P. Rasumowskyana,* and *P. charkowiensis* are thought by some students of the genus to be hybrids, and our finding of marked variability in the seedlings obtained in crosses of several of these with types known to be members of pure species seems to confirm this view. In this paper the names of several of the poplars commonly grown as clons and definitely known to be hybrids will be used as common horticultural terms rather than as Latinized specific or varietal names.

It should be noted, however, that the nomenclature is much confused for the two species commonly called the Necklace Poplar and the Northern Balsam or Tacamahac Poplar. Sargent[3] concludes that the name *P. balsamifera,* long applied to the latter, seems to be-



EIGHT FOOT GROWTH IN ONE SEASON

Figure 3

At measuring rod, hybrid of *P. nigra betulifolia* × *P. trichocarpa;* at left, hybrid of *P. nigra* × *P. trichocarpa.* Growth of 8 feet made in one summer from cuttings planted during the previous spring in nursery at Strathglass Farm near White Plains, N. Y. Here the growing season is longer than at Frye, Maine, and the growth made from cuttings is often three feet more than that made in Maine. The few lateral branches were removed during the summer.

Black poplar hybrids seventeen years old have been known to average over an inch a year increase in diameter of trunk and to yield over nine-tenths of a cord of wood. It appears that some of these new hybrids are likely to prove even better wood producers. It is quite possible that one or more of the 13,000 seedlings which were tested in those experiments will be the basis of varieties destined to play an important part in furnishing the pulpwood which is becoming such a serious drain on natural forests.

long to the former, the northern form of which he calls *P. balsamifera virginiana*. For the northern balsam poplar the name *P. tacamahacca* first applied by Miller should apparently be used.

The Selection of the Best Hybrids

The rather large number of different hybridizations that produced offspring, and the numerous seedlings (about 13,000) that were obtained, afforded a wide range of types and individuals from which to select seedlings of greatest merit. The chance of obtaining valuable hybrids was, it would seem, greatly increased by such a program of extensive hybridization. A special effort has been made to determine those seedlings which will be most valuable as trees in reforestation for pulpwood.

The methods used in the breeding and in the growing of seedlings during the first two years have already been reported.[9] On the basis of the behavior, and especially of the vigor of growth during the second year, a total of about 600 seedlings was selected for nursery propagation and study. In this preliminary selection the best seedlings in *each* group of hybrids were chosen, except for those series that contained only plants obviously of no value. The performance of these hybrids was critically judged in extensive nursery propagation in respect to comparative vigor of growth, resistance to disease, and the selection class was reduced to include only the very best. The seedlings that were not propagated were planted as rooted trees in a forestation planting and later rooted cuttings of the selection plants were also thus planted.

TABLE I.—List of the Hybridizations

The following is a list of the various poplars used as parents in the hybridizations made by the writers. They are arranged in alphabetical order within the main groups of poplars, and numbered in sequence, and the extent to which each was used in hybridizations is indicated by the use of the numbers assigned in the sequence. Those crosses which gave plants that are now included in the *final* selections as having the most promise for reforestation trials are indicated by bold face type. The number of seedlings grown for each cross is indicated in italics under the female parent. Thus in the cross of *P. alba* and *P. alba nivea* 67 seedlings were grown, none of which was retained in the final selections.

I. The White Poplars
1. *Populus alba* ♀ × *2 (67)*; 3 *(8)*; 4 *(34)*; 6 *(22)*; 7 *(16)*.
2. *P. alba nivea* ♂ × 1.
3. *P. canescans* ♂ × 1.

II. The Aspens
4. *P. adenopoda* ♂ × 1, 17.
5. *P. grandidentata* ♂ × 10, 31, 32.
6. *P. tremula* ♂ × 1, 8.
7. *P. tremula Davidiana* ♂ × 1.
8. *P. tremuloides* ♀ × 6 *(11)*.

III. The Black Poplars and Cottonwoods
9. *P. angulata* ♀ × 10 *(583)*; 11 *(248)*; 12 *(99)*; 16 *(203)*; 21 *(214)*; 22 *(60)*; 25 *(214)*; **26** *(205)*; **34** *(264)*.
10. *P. balsamifera virginiana* ♀ × 5 *(178)*; 10 *(138)*; 11 *(18)*; **12** *(189)*; 16 *(208)*; 21 *(183)*; 22 *(7)*; 25 *(216)*; **26** *(245)*; **34** *(705)*.
♂ × 9, 10, **13**, 15, 18, 19, 23, 31, 33.
11. Cottonwood (unidentified) ♂ × 9, 10, **13**, 15, 18, 19, 31.
12. *P. caudina* ♂ × 9, **10, 13,** 18, 26, **29, 30, 31,** 32.
13. *P. charkowiensis* ♀ × **10,** *(288)*; **11** *(267)*; **12** *(266)*; 16 *(263)*; **21** *(312)*; 22 *(52)*; 25 *(188)*; **26** *(249)*; **34** *(221)*.
14. *P.* clon Eugenei ♂ × 17, 23.
15. *P. Fremonti* ♀ × 10 (7); 11 (9); 16 *(108)*; 21 *(194)*; 25 *(217)*; 26 *(69)*; 34 *(125)*.
16. *P. incrassata* ♂ × 9, 10, 13, 15, 18, 19, 29, 31, 32.
17. *P. nigra* ♀ × 17 (6); 14 *(49)*; 17 *(184)*; 20 *(44)*; **27** *(217)*; **28** *(377)*; 32 *(2)* **34** *(200)*.
18. *P. nigra baatanicorum vitrum* ♀ × 10 *(6)*; 11 *(60)*; 12 *(51)* 16 *(10)*; 21 *(157)*; 25 *(170)*; 34 *(121)*.
19. *P. nigra betulifolia* ♀ × 10 *(11)*; 11 *(11)*; 16 *(141)*; 21 *(65)*; 25 *(166)*; **34** *(209)*.
20. *P. nigra Italica* (clon Lombardy) ♂ × 17, 23.

The oldest of these trees are now seven years old from seed, they have been in the forestation planting for five years, and many of them give some indication of what type of mature tree may be expected. On the basis of their excellent showing in the forestation planting certain seedlings not included in the earlier selections have recently been chosen for propagation.

Vigor of growth. Many of the hybrids obtained possess "hybrid vigor" to a remarkable degree. The performance to date in the nursery indicates that many of the hybrids surpass both of their parents and also the older hybrids in rapidity of growth under comparable nursery conditions. Cuttings fourteen inches long of various hybrids which were planted on ordinary farm land near New York City have reached a height of eight and one-half feet during the first growing season. The elite seedlings are being propagated from cuttings to give clonal varieties and hence the vigor inherent in a seedling is maintained and a uniform and reliable stock is secured. The capacity for rapid growth is a quality of first consideration in the selection of choice seedlings.

Ability to root from cuttings. Ready propagation by cuttings simplifies the nursery work and the use of cuttings for reforestation planting greatly reduces the cost of such plantings. The various hybrids show differences in rooting qualities, ranging from those which, practically speaking, cannot be rooted under nursery conditions to those which root almost one hundred per cent. It is possible that methods of handling cuttings to insure their rooting could be devised even for those poplars, such as the hybrids of *P. alba* and *P. adenopoda*, that do not root

TABLE I (Continued)

21. *P. nigra plantierensis* ♂ × 9, 10, **13,** 15, 18, 19, *26,* **29,** 31, 32, 33.
22. *P.* clon Robusta ♂ × 9, 10, 13, 32.
23. *P. Sargentii* ♀ × 10 (*72*); 14 (*50*); 20 (*25*); 23 (*35*); **26** (*149*); **27** (*309*); 28 (*51*); 32 (*14*); 34 (*233*).
24. *P.* clon Serotina ♂ × 26.
25. *P.* clon Volga ♂ × 9, 10, 13, 15, 18, 19, 26, **31,** 32.

IV. The Balsam Poplars, and the Older Hybrids strongly Balsam in Character.

26. *P. berolinensis* ♀ × 12 (*8*); 21 (*17*); 24 (*29*); 25 (*62*); 26 (*31*); **34** (*27*). ♂ × **9, 10, 13,** 15, 26, **23, 29,** 31, **32, 33.**
27. *P. berolinensis Rossica* ♂ × **17, 23.**
28. *P. laurifolia* ♂ × **17,** 23, 33.
29. *P. Maximowiczii* ♀ × **12** (*179*); 16 (*2*); **21** (*145*); **26** (*112*); **34** (*5*).
30. *P. Petrowiskyana* ♀ × **12** (*25*).
31. *P. Rasumowskyana* ♀ × 5 (*2*); 10 (*56*); 11 (*30*); **12** (*70*); 16 (*25*); 21 (*76*); **25** (*81*); 26 (*183*); 34 (*148*).
32. *P. Simonii* ♀ × 5 (*32*); 12 (*99*); 16 (*75*); 21 (*176*); 22 (*1*); 25 (*155*); **26** (*189*); 34 (*44*). ♂ × 17, 23.
33. *P. tacamahacca candicans* clon Balm of Gilead ♀ × 10 (*6*); 21 (*40*); **26** (*82*); 28 (*6*).
34. *P. trichocarpa* ♂ × **9, 10, 13,** 15, **17,** 18, **19,** 23, **26, 29,** 31, 32.

The following is a list of cross-pollinations from which capsules with seeds or seed-like structures were obtained but which did not germinate.

P. Sargentii (23) × *P. adenopoda* (4)
P. berolinensis (26) × *P. incrassata* (16)
× *P.* clon Robusta (22)
P. Petrowiskyana (30) × *P. berolinensis* (26)
× cottonwood (11)
P. Rasumowskyana (31) × *P.* clon *robusta* (22)
P. Simonii (32) × *P. grandidentata* (5)
P. Simonii (32) × cottonwood (11)
P. clon Balm of Gilead (33) × cottonwood (11)
P. Maximowiczii (29) × *P. balsamifera virginiana* (10)
× cottonwood (12)
P. Fremontii (15) × *P. caudina* (12)

It is not to be considered that the failure to obtain capsules or viable seeds in the cross-pollinations noted above indicates that hybrids of these crosses can not be obtained. Failure to obtain seed because non-viable pollen was used may have operated in certain cases.

A COTTONWOOD-ASPEN HYBRID

Figure 4

One of the 178 hybrids produced of *P. balsamifera virginiana* × *P. grandidentata*. These hybrids strongly resemble the pollen parent. They root poorly from cuttings and they grow very slowly, thus showing lack of "hybrid vigor" which many of the other hybrids possess. These hybrids were injured by a fungus disease which did not attack any of the other hybrids grown in Maine.

readily from branch cuttings, but at present it seems that final selections of hybrids for possible use in reforestation should include only those that root readily from stem cuttings. Fortunately many of the hybrids root more readily from cuttings than do their parents.

Hardiness. The hardiness desired of hybrids embraces such qualities as the ability to start growth early, to grow rapidly all summer, and to ripen wood and buds so that there is little or no frost injury in autumn or winter injury later. Some of the seedlings and especially those of *P. Maximowiczii* parentage suffer from frost and winter injury in Maine, but most of the new hybrids appear to be fully hardy.

Resistance to disease. A rust fungus (*Melampsora medusae*) severely attacks the hybrids of several types of poplars. The hybrids of *P. angulata* and *P. balsamifera virginiana* are especially liable to severe injury as nursery stock, and some of the finest seedlings in respect to vigor of growth have been rejected for this reason. The various canker diseases (particularly those caused by fungi of the genus *Valsa*) do much damage to cuttings that are not handled properly and they may cause much injury to trees in forest plantations, especially where there is poor growth. Special attention is being paid to the degree to which the different types of hybrids are immune or resistant to the various diseases.

Shape of tree and habit of branching. For pulpwood purposes a tree with a rather tall upright habit of growth and with a weak development of lateral branches seems desirable. Some of the parents are trees of broad spreading habits of growth but others are of more erect or even strongly columnar habit. Differences in branching habit were evident in the seedlings and many of the first-choice seedlings have an upright habit of growth. Certain of the series of hybrids are rather uniformly columnar as will be noted later in this article.

The habit of growth will need further study in mature trees and in reforestation plantings in which the trees are grown at different spacings.

Series of Poplar Hybrids Containing Final Selection Plants

At the present writing (the summer of 1932) a total of 69 individual seedlings have been selected as plants of special merit for use in reforestation. The following tabulation gives the parentage of these, the total number of seedlings grown in each hybridization and the number of plants selected. The names of parent species belonging to the Black Poplar and Cottonwood Group are printed in *italics* and those of the Balsam Group are in ***bold face*** No other parentages are involved in the seedlings classed as the very best.

The Pyramidal and Columnar Habits of Growth Among the Seedlings

Several of the poplars used as parents have a columnar or upright habit of growth. A decidedly upright habit with well developed main trunk and few laterals may be a desirable character in trees that are used in reforestation, and hence the branching habit has been studied in the seedlings.

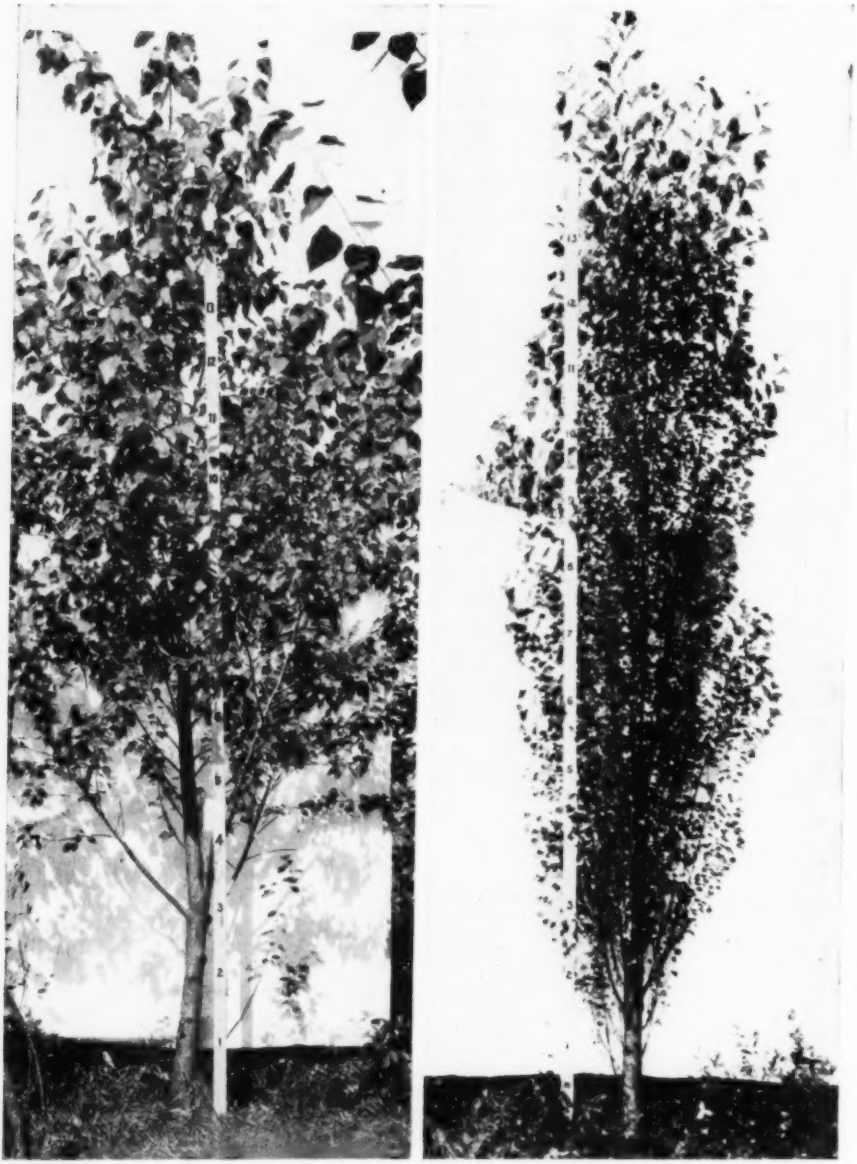
There seems to be a tendency for young poplar seedlings to grow in an upright manner. They may continue in this or they may become rather widespreading. But some seedlings are much branched from the first while others have a strong main trunk with few large branches. There are various types of trunk and of branching habits involving many gradations between a widely spreading crown and what may be called upright, columnar, pyramidal, and fastigiate forms. For the present the writers will speak of all these classes in these seedlings as pyramidal.

The series composed of seedlings all of which are at present writing noticeably and rather uniformly pyramidal are as follows:

P. charkowensis × *P. berolinensis*
P. charkowiensis × *P. nigra plantierensis*
P. charkowiensis × *P.* clon Volga
P. nigra × *P.* clon Eugeni
P. nigra × *P. nigra Italica*
P. nigra baatanicorum vitrum × unidentified cottonwood

TABLE II.—Series Containing Final Selection Plants

Seed Parent × Pollen Parent	Total Number of Seedlings	Number in Final Selections
P. angulata × ***P. berolinensis***	205	2
" × ***P. trichocarpa***	264	1
P. balsamifera virginiana × ***P. berolinensis***	245	3
" × *P. caudina*	189	1
× " ***P. trichocarpa***	705	3
P. charkowiensis × *P. balsamifera virginiana*	288	4
" × ***P. berolinensis***	249	3
" × *P. caudina*	266	5
" × *P.* clon cottonwood	267	2
" × *P. nigra plantierensis*	312	2
" × ***P. trichocarpa***	221	2
P. nigra × ***P. berolinensis Rossica***	217	2
" × ***P. laurifolia***	377	10
" × ***P. trichocarpa***	200	3
P. nigra betulifolia × ***P. trichocarpa***	209	1
P. Sargentii × ***P. berolinensis***	149	2
" ***P. berolinensis Rossica***	11	2
P. berolinensis × ***P. trichocarpa***	27	2
P. Maximowiczii × ***P. berolinensis***	112	8
" × *P. caudina*	179	1
" × *P. nigra plantierensis*	145	1
" × ***P. trichocarpa***	5	3
P. Petrowskyana × *P. caudina*	25	1
P. Rasumowskyana × *P. caudina*	70	1
" × *P.* clon Volga	81	1
P. Simonii × ***P. berolinensis***	189	1
P. tacamahacca clon Balm of Gilead × ***P. berolinensis***	82	2



SIX-YEAR-OLD HYBRIDS

Figure 5

At left. One of the hybrids of *Populus balsamifera virginiana* × *P. trichocarpa.* Six years old from seed and four years in a forestation planting; 20 feet tall. A total of 597 seedlings of this cross were grown; they were very vigorous but nearly all of them were severely injured by rust. This particular seedling was one of the few hybrids of this cross that were only slightly affected by this disease.

At right. Hybrid of *P. charkowiensis* × *P. caudina.* Age same as noted above; 16 feet tall. This plant is typical of many seedlings that have a pyramidal habit of growth.

P nigra baatanicorum vitrum × *P. incrassata.*
P. nigra baatanicorum vitrum × *P. nigra plantierensis*
P. nigra baatanicorum vitrum × clon Volga
P. nigra betulifolia × *P. balsamifera virginiana*
P. nigra betulifolia × *P. nigra plantierensis*
P. nigra betulifolia × *P. trichocarpa*
P. Simoni × *P. nigra plantierensis*
P. Simoni × *P.* clon Volga

There are several series of seedlings of which some are pyramidal and some are wide-spreading and of these the following may be reported:

P. nigra betulifolia × *P. incrassata.* The larger and more vigorous seedlings of this cross can hardly be called columnar but a few of the smaller ones have branches that are very close-growing and at the present time may be considered as columnar.

P. Maximowiczii × *P. berolinensis.* Most of these seedlings have the spreading habit characteristic of the female parent but a few are somewhat columnar.

P. Rasumowskyana × *P. nigra plantierensis.* About half of these seedlings are columnar.

P. Simoni × *P. berolinensis.* Some of these seedlings have widely spreading branches, others are columnar and between these extremes there are many gradations.

Of the parents of the hybrids listed above, the *P. nigra Italica* (clon Lombardy, the *P.* clon Volga, and the *P. nigra plantierensis* are all decidedly pyramidal and they are all male clons. The *P. charkowiensis* is said to be a hybrid with one parent a fastigiate black poplar. The character of the seedlings indicates that the pyramidal habits of growth are decidedly hereditary in poplars.

Summary

In this breeding project 34 different poplars were involved as parents, including three white poplars, five aspens, seventeen black poplars and cottonwoods, and nine balsam poplars or hybrids strongly balsam in character. Male and female trees of the same type were available only for *P. nigra, P. balsamifera virginiana, P. Simonii,* and *P. berolinensis,* and a progeny of each of these was grown. Also a total of 99 cross-combinations between the 34 species, varieties and hybrids gave seedlings. Most of these were crosses between members of the same general group, but numerous wide crosses also gave progeny, such as the white poplar *P. alba* × the aspens *P. adenopoda* and *P. tremula;* the cottonwood *P. balsamifera virginiana* × the aspen *P. grandidentata;* and numerous combinations between black poplars or cottonwoods and balsam poplars.

A total of about 13,000 poplar seedlings, almost all of which were hybrids, were grown and subjected to critical selections on the basis of vigor of growth, hardiness in Maine, resistance to disease, ability to root from cuttings, and habit of growth. It was the aim to select for propagation those seedlings which give greatest promise of value for use in reforestation, especially in the production of pulp wood. At the present time a total of 69 different seedlings are included in the elite class.

A survey of Table II shows that 19 out of the 34 parents used in the various hybridizations are involved as parents of the elite plants. Ten of these are members of the black poplar and cottonwood group and nine are balsam poplars, including certain older hybrids with characters of these groups. There were also many other fine seedlings of parentage not represented in the final selections, and many sister hybrids of the elite seedlings were equal in excellence to the selected plants. Many of remarkable vigor were rejected because of the severe injury which they suffer from rust. In general, the offspring of crosses between *P. balsamifera virginiana, P. angulata,* and *P. Sargentii* suffered most severely from the rust disease.

As the final selections now stand they include 27 combinations of hybrids in-

volving black poplars, cottonwoods and balsam poplars. There are five combinations and 14 individual seedlings of hybrids between different types of black poplars and cottonwoods (see Table II). Of hybrids involving only balsam poplars there are five combinations with 16 individuals. The hybrids between black poplars or cottonwoods and balsam poplars or hybrids involve 17 different combinations and 39 individuals. On the basis of these results the crosses between members of these two groups of poplars have been most productive of selected individuals.

Several of the poplars that have given progeny of greatest excellence may be noted. The necklace poplar *P. balsamifera virginiana* is represented in the selection plants in four combinations. *P. charkowiensis* is a parent in six hybrid series which include 18 selections and the *P. nigra* and its two varieties *plantierensis* and *betulifolia* are involved in five combinations. Of the balsam poplars the so-called *P. berolinensis*, and the *P. berolinensis Rossica*, are parents in nine different series of hybrids which contain final selections. The *P. Maximowiczii* was used in five combinations in which from 5 to 179 seedlings were obtained, and almost all of these were plants of remarkable vigor and general excellence except for frost injury of nursery stock. *P. trichocarpa*, the giant poplar of the northwest, is represented in seven progenies containing selection plants. The *P. laurifolia* ♂ was used in only three crosses; with the *P. nigra* the progeny was of such exceptional vigor and freedom from rust that 10 sister hybrids have remained in the elite group.

The chief value of these new hybrid poplars is as quick growing trees for the production of pulpwood or cheap timber for various uses such as material for excelsior or cellulose. For such purposes it is certain that the best of these new hybrids surpass the older hybrids, primarily because they are more vigorous in growth, at least in nursery tests, and are more resistant to rust. Some of these new hybrids, and especially those with pyramidal and columnar habits of growth may be valuable as ornamentals, particularly if they prove more resistant to the canker diseases which are very injurious to the old Lombardy poplar (*P. nigra Italica* clon Lombardy). The large number of new hybrids with columnar habit provides material for the selection of individuals of merit.

It may perhaps be assumed that many of the hybrids that are hardy and of vigorous growth in Maine will behave in much the same way over a considerable area of the temperate regions. Possibly the hybrids, and especially those with *P. Maximowiczii* as a parent, that are not fully hardy in Maine due to continued growth into autumn may be valuable further south.

It is to be recognized that further trials in reforestation plantings or as shade trees would no doubt lead to a reduction in the number of hybrids that are to be considered most valuable and most suitable for culture especially in areas other than Maine.

Ten of the hybrids that show special merit and that are being propagated as clons have now been given horticultural names as follows:—Andover Poplar, Androscoggin Poplar, Frye Poplar, Geneva Poplar, Maine Poplar, Oxford Poplar, Rochester Poplar, Roxbury Poplar, Rumford Poplar and Strathglass Poplar. This will allow distribution and trial in various regions under definite and established names.

The work of breeding poplars reported above was conducted under the auspices and with the financial support of The Oxford Paper Company and with the cooperation of the N. Y. Botanical Garden. The project was initiated by The Oxford Paper Company in the spring of 1924 chiefly through the interest of Professor Ralph H. McKee who was then in the employ of the Company as the Director of Research. Professor McKee gave his hearty support to the plans and methods of work developed by the authors.

The work of the hybridizations was done with the collections of poplars planted at The New York Botanical

Garden and at Highland Park, Rochester, N. Y., and with wild trees of *Populus balsamifera virginia* growing on the grounds of The New York State Experiment Station at Geneva, N. Y. The writers are indebted to various persons for permission to use the trees in breeding and for various facilities in the prosecution of the work. To Mr. R. E. Horsey and to Mr. William Edson the writers are indebted for much help and information regarding the identity and the origin of various of the poplars utilized in the breeding at Highland Park.

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Twins in Cattle

ZWILLINGSFORSCHUNG BEIM RIND, *by* C. Kronacher, 1932, Verlag von Paul Parey in Berlin SW 11.

AFTER citing from tne literature, cases of what seems to be monozygotic twinning in the horse, in the pig, and in sheep, the author opens his discussion of the situation in cattle with the statement that the latter, of all domestic animals, represent the most suitable material for twin-investigations. The chief favorable circumstance is, undoubtedly, the high percentage of twin-births in cattle, namely, from 2 to 2.7%, of which 51.06% (according to Tuff), or 53.01% (according to J. Johansson) are same-sexed. The occurrence of monozygotic twins in cattle is suggested statistically by the slight preponderance of twins of the same sex as compared with those of opposite sexes, and morphologically by the relative frequency of double monsters showing various degrees of separation.

This introductory discussion is followed by an analysis of the various methods of recognition of monozygotic twins as applied to cattle. The presence of a single corpus luteum in the ovaries of the mother, however valuable as auxiliary evidence of the monozygotic origin of a given pair of twins, must not be considered an absolute proof of such origin. Thus, pathological conditions in the ovaries may complicate the picture; a single follicle may have contained two ova, or a single ovum may have had two nuclei fertilized by the same sperm-cell. A single afterbirth, whenever procurable, may also be of secondary importance in the diagnosis, although C. Keller has uncontrovertibly shown that monochorial twins are the rule in cattle, goats, and sheep. The author suggests also here, as in the case of human twins, the general correlation method as the most reliable. This method, however, will become more accurate as statistical data on variability of hereditary characters in cattle are accumulated.

A complete correlation-diagnosis includes:

I. *Physical characteristics:* General development of the body and of its

parts; the progression of the body-weight; size-relationships of the head, the rump, the extremities; peculiarities and similarities in the structure of the eyes, the ears, the teeth, the lip-papillae, the withers, the shoulder, the back, the sacrum, the pelvis, the tail, the joints; pigmentation of the visible mucous membranes, especially of the tongue and of the palate; the nature of the skin, of the hair; the number, position, distribution as well as regularities and irregularities of the hair-whorls; concordance in coat-color, striking similarity and mirror-imaging in the distribution and shape of spots and special marks; the possession of similar pathological formation, etc.

Nose-Prints of Twins

A particularly valuable character in the physical diagnosis is the nose-print as it shows individual variations and displays remarkable similarities in general pattern in animals which, on the basis of general concordance, have been diagnosed as identical twins.

In case of loss, through death or slaughter, of the animals under observation, a supplementary examination and comparison of their internal organs as to size, structure, deviations from the normal, etc., will be found helpful.

II. *Physiological characterstics:* The general phenomena associated with the sexual cycle; onset of sexual maturity; fertility, duration of gestation; lactation, both quantitatively and qualitatively, on similar or different diets; metabolism, blood, as to both serological properties and constitution; resistance or susceptibility to disease, etc.

III. *Psychic properties:* These are, of course, not as important as in the case of man, but still the reactions of the respective animals toward the other members of the herd or toward their human attendants are known to constitute individual traits and may thus be used in twin-diagnosis.

Thirty-five pairs of twins, the animals in each pair being of the same sex, were examined by the above methods. In five of these, the findings were interpreted by the author, with a greater or lesser certainty, to indicate a monozygotic origin for each pair; particularly convincing were the results in the case of two pairs, each of which revealed an astonishing concordance. In nine other cases, the probability of monozygotic origin was not excluded although not absolutely warranted by the data. The remaining twenty-one pairs were decidedly dizygotic as conclusively shown by the correlation-diagnosis.

This is the first study of twins in domestic animals in which the method of diagnosis of monozygosity now used for human twins has been applied. This method bids fair to add greatly to our knowledge of the detailed genetics in the animals studied.

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Eugenic Sterilization in Mexico

THE state of Vera Cruz is the first Latin-American commonwealth to adopt eugenic sterilization. A law signed by Governor Adalberto Teffieda on November 26, 1932, charges the Bureau of Eugenics and Mental Hygiene of the Department of Health to have sterilized such persons as are found to be suffering from incurable and hereditary forms of mental disease, or mental deficiency, and authorizes it also to sterilize criminals where such action seems to be desirable. Provision is made for free birth control clinics as well, while the Bureau is further directed "to promote within the state the creation of private eugenics societies organized by competent persons." This law was drafted largely by Salvador Mendoza, a young lawyer, sociologist, and economist who has during the last decade played an active part in remodeling the Mexican legal codes.

Paul Popenoe.

HYBRIDIZING DIAMOND-BACK TERRAPINS

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U. S. Bureau of Fisheries

THE Chesapeake and the Carolina terrapins are classified as two varieties or subspecies, *Malaclemmys centrata concentrata* and *M. centrata centrata* (Stejneger and Barbour,[3] pp. 131-132). Their general ranges of distribution meet at Cape Hatteras, though considerable overlapping of the two varieties takes place along the North Carolina coast. Natural hybridization undoubtedly occurs in this vicinity, as pointed out subsequently.

In general, the Chesapeake terrapin reaches a somewhat larger size than the Carolina terrapin. It also has a smaller head and the carapace is proportionately broader posteriorly than in the Carolina terrapin. Many intermediate individuals are seen in the vicinity of Beaufort, N. C. Dealers who have handled diamond-backs for many years, and who are well aware of the usual difference between the Chesapake and the Carolina forms, cannot definitely place these with either variety. Such intermediate individuals very probably are hybrids, i. e., the result of natural cross breeding between the two varieties.

Terrapins consisting of the two varieties (with a preponderence of the Carolina terrapin) together with some intermediates ("hybrids"), mostly caught locally, have been propagated at the U. S. Fisheries Biological Station, Beaufort, N. C., since 1909. In 1914 experiments in cross breeding the local terrapins (which for convenience will be designated the Carolina terrapin in this paper) with the Texas terrapin (*Malaclemmys pileata littoralis*) were undertaken.† The Texas terrapin grows larger than the Carolina terrapin, but it is regarded as inferior in flavor. From a practical viewpoint, it was thought that possibly a superior race, i. e., a quick growing terrapin of large size, yet well flavored, might result from hybridizing the two. The purpose of this paper is to report on the results of these cross breeding experiments.

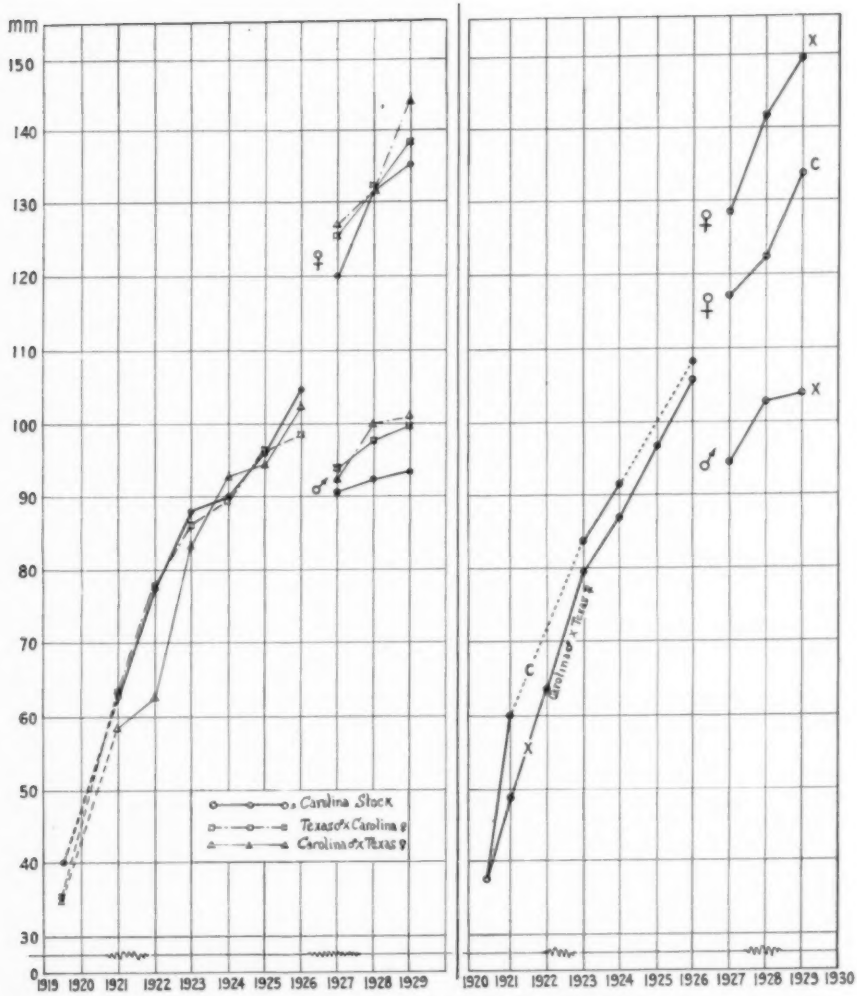
Methods of Conducting the Experiments

Two lots of female terrapins, consisting of ten each, one of Carolina and the other of Texas terrapins, were placed in separate pens. Males of the opposite species were to be introduced only after infertile eggs had been produced. This procedure would make it certain that the offspring resulting when the crosses were made would actually be hybrids. It was thought that the eggs would cease to be fertile certainly by the second breeding season, following the separation of the sexes. However, this did not prove to be the case, for as already reported by the present investigator[5] both lots of females produced a high percentage of fertile eggs during the first two breeding seasons following their separation from males, a somewhat lowered percentage of fertile ones the third season, and a very few fertile ones the fourth season. Thereupon, males were introduced. The first hybrids, therefore, were secured in 1919, five years after the experiments were begun.‡

*Published by permission of the Commissioner of Fisheries.

†This experiment was planned and started by William P. Hay of the Washington, D. C., Public Schools, who at that time was a temporary investigator with the Bureau of Fisheries.

‡It seems to be of interest to report that the percentage of fertility of the eggs ran high during the first laying season following the introduction of males. Fertility apparently was



GROWTH CURVES OF TURTLE HYBRIDS

Figure 6

At left is shown the growth of three groups of the 1919 brood; reciprocal crosses between Carolina and Texas terrapins, and a control group of straight Carolina stock. At the right is a comparative growth curve of a Carolina group (*C*) and a group of Carolina ♂ × Texas ♀ Hybrids (*X*). The hybrids reached a slightly larger size than the straight Carolina stock but the differences are so slight that it is clear that this cross shows little hybrid vigor. The numbers involved, and the sex-distribution, are given in Tables I and II.

The large majority of the young of both crosses bore unmistakable evidence of relationship to the Texas terrapin, one of the chief characters of that species being prominent knobs on the vertebral plates of the carapace. However, the knobs were not equally prominent in all the offspring and a few were scarcely separable from straight Carolina stock. The hybrids of the two crosses were not evidently distinct.

At the age of about eight months 80 young hatched from eggs laid by Carolina females crossed with Texas males survived and were then placed in a separate pen, having previously been cared for in a nursery house. At the same time, 100 young of the reciprocal cross were placed in another pen, and 100 young of straight Carolina stock, to serve as a control, were placed in a third pen. The three lots received identical treatment throughout the experiment. Unfortunately, rats entered the pens when the terrapins were still quite small and destroyed many of them, especially of the hybrids. A few died of disease and natural causes. The result was that only 32 animals of the Carolina ♂ × Texas ♀ cross, 53 of the reciprocal cross, and 70 of the control lot survived to maturity. Because of the comparatively small number reaching maturity, the results with respect to sex ratio, as well as the rate of growth are less reliable than they would have been had the depredations by rats been avoided.

In the spring of 1921 a third lot of hybrids of the 1920 brood consisting of 100 young of the Carolina ♂ × Texas ♀ cross was set aside, together with a second lot of 100 young of straight Carolina stock of the same age (to serve as a control). Again the number was greatly reduced by rats and only 56 hybrids and 26 females of the straight stock (the males having been discarded as soon as recognized) were grown to maturity.

Rate of Growth

The figures and tables appended show that the rate of growth of the hybrids (both crosses) and of the controls (Carolina stock) of the brood of 1919, was almost identical. At the age of two years the average lengths of the surviving hybrids of the reciprocal crosses and of the control were within 4 millimeters of each other. On October 2, 1926, when the animals were seven years old, and nearly all of them had developed external sex characters sufficiently to permit recognition of the sexes, the average length of the controls (104.7 millimeters) exceeded the average length of the Texas ♂ × Carolina ♀ by 6.4 millimeters, and the average of the reciprocal cross by only two millimeters.*

Finally at the age of ten years (October 23, 1929), when the animals were nearly all mature and breeding, the average length of the hybrid males of both crosses was slightly greater than that of the control males. The differences between the hybrid and the control females, which alone are important in commerce, were very small (Figure 6).

During the first six years of life of the hybrids of the 1920 brood, the rate of growth, as in the older lots, was about equal to that of the control lot.

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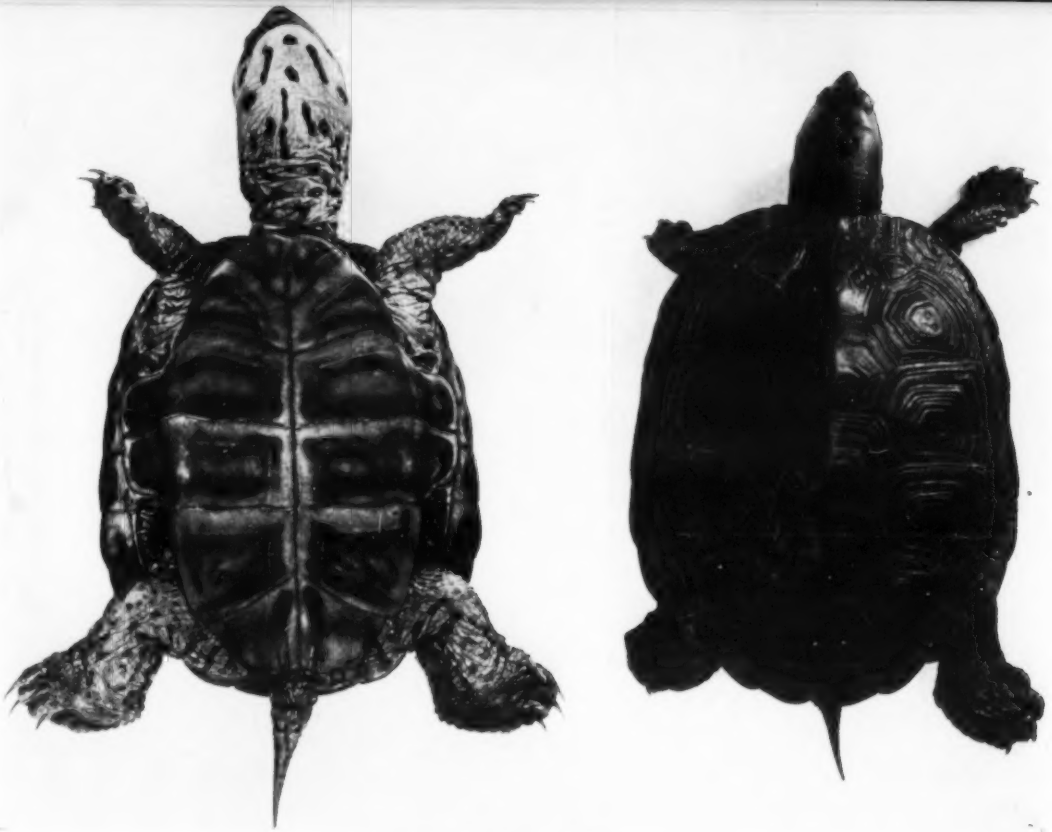
just as high that year as it would have been if males had been penned with the females continuously. For example, one lot (Carolina females × Texas males) laid 145 eggs of which 141 hatched.

*Tables 2 to 4 show that the large majority of the hybrids were males, whereas an almost reverse sex ratio existed among the Carolina lot. While the male does not grow as large as the female, no evidence has been secured indicating that growth is slower in this sex than in the female prior to the time of the development of the external sexual characters. Therefore, the average length among the young probably was not affected by the difference in the sex ratio.



THE CAROLINA TERRAPIN

Figure 7

The diamond-backed terrapin is found as two sub-species with a range from Chesapeake Bay to the coast of the Carolinas and Georgia. These specimens, shown three-quarters natural size are females about seven years old. The age can be told by the number of rings on the plates of the shell on the back. The width of these rings, like the growth rings of trees, shows the extent of each year's growth. Thus, the turtle at the right had a tremendous spurt of growth in the fourth and fifth years, and the two succeeding years' growth was much less. It was thought that hybridization with the somewhat larger Texas species might produce a form of more rapid growth and possibly of larger size. The hybrids were, however, a disappointment from a practical point of view, for the growth rate and adult size were only slightly increased.

Thereafter, the hybrids took on an unusual spurt of growth and maintained their advantage to maturity. Figure 6 shows the average growth-rate of hybrids and control of this brood.

The hybrids of the 1920 brood, having grown very rapidly between the ages of six and nine years, were larger also than the hybrids of the same parents, as well as those of the reciprocal cross of the brood of the previous year. (See Figure 6 and tables).

In checking the records, it becomes evident that the hybrids of the brood of 1920 were larger at the age of nine years than any other lot of straight Carolina stock at the same age in captivity during the entire course of the propagation experiments, conducted from 1909-1930.

While no control lots consisting of straight Texas stock of the broods of 1919 and 1920 were available, the rate of growth of the hybrid lots may be compared with a lot of Texas terrapins of the broods of 1912 kept until the animals were eight years old. According to Barney[1] the straight Texas stock grew rather slowly during the first three or four years of life (that is, more slowly than Carolina terrapins of the same brood) and thereafter the rate of growth was rather rapid. The Texas terrapins of the brood of 1912 at the age of three years, for example, had attained an average length of about 80 millimeters (compared with nearly 90 millimeters in Carolina terrapins of the same brood). The rate of growth in the straight Texas stock during the first several years of life, therefore, was scarcely faster than in the three lots of hybrids (two crosses of the brood of 1919 and one of the brood of 1920) already discussed. Thereafter, growth appears to have been considerably faster. At the age of five years, for example, the lot of straight Texas stock had attained an average length of about 106 millimeters, and at seven years, 132 millimeters. Therefore, these animals had attained a far larger average size at these ages than any of the hybrid lots. (See tables). At the age of eight years, the Texas terrapins were still considerably larger even than the hybrids of the 1920 brood, which, as already pointed out, were gaining growth rapidly at this age and continued to grow until last measured at the age of nine years.

It is evident from the results obtained by cross breeding Carolina and Texas terrapins that hybrid vigor, sometimes manifested in species crosses, did not display itself perceptably in so far as the rate of growth was concerned in the lots of hybrid terrapins here considered. Although the Carolina ♂ × Texas ♀ cross of the brood of 1920 did show a rather unusual spurt of growth rather late in life, or at an age when pure bred Carolina terrapins generally have become mature and grow very little or not at all. Furthermore, this lot of hybrids grew rather larger than any of the straight Carolina terrapins. However, the offspring of the same parents of the previous brood did not give any manifestation of this rather late growth and attainment of large size.* Therefore, the constant attainment of large size of the offspring of Carolina males crossed with Texas females apparently may not be expected.

Sex Ratio

It was pointed out by the present writer[2] that a sex ratio of 1 male to 6.4 females existed in 1927 among the straight Carolina terrapins present at Beaufort at that time. The latest full census of all terrapins on hand was taken in 1928, when a few additional lots had reached a sufficiently large size to admit the recognition of the sexes. At this last enumeration, the lots of Carolina terrapins grown in captivity consisted of 200 males and 1,233

*Much variation in the rate of growth and average size attained has existed among the many lots of Carolina terrapins grown to maturity. Such variation sometimes has appeared in lots of the same brood. The reason or reasons for such fluctuations are not yet evident.

females, representing a sex ratio of 1 male to 5.9 females. The extremes of sex ratio in the Carolina terrapins were met in the brood of 1911, consisting of 148 females and no males, and in the brood of 1919, consisting of 54 males and 93 females, or a ratio of 1 male to 1.7 females.

In view of the scarcity of males among the pure bred Carolina terrapins, it is very interesting to find in the three lots of hybrids on hand as many as 86 males to 53 females, or a sex ratio of 1.66 males to 1 female. Furthermore, the sex ratio does not differ greatly in the various lots. The Texas ♂ × Carolina ♀ hybrids of the 1919 brood, consist of 32 males and 21 females, the reciprocal hybrids of the same year consist of 21 males and 11 females, and the single lot of hybrids of a Carolina ♂ × Texas ♀ cross of the brood of 1920 consists of 35 males and 21 females.

Most of the lots of terrapins on hand were selected for large size and vigor at eight to twelve months of age. However, a few lots were unselected, and the animals constituting one lot (brood of 1912) were selected as runts. It appears that selection for large or small size does not affect the sex ratio. At any rate, the hybrids, too, were selected in part and, therefore, the sex ratio should not have been affected differently. If this preponderence of males is characteristic of these hybrids, it would be a decided disadvantage from an economic viewpoint to hybridize Texas and Carolina terrapins, because males have little commercial value.

Fertility

The three lots of hybrids discussed all produced eggs for the first time in 1928. Therefore, the hybrids of the brood of 1920 laid eggs when a year younger than the other two lots. Earlier sexual maturity appears to be correlated with size, for it has been pointed out above that the hybrids of the brood of 1920 grew faster than those of the brood of 1919, and their average size actually was greater in 1928. Evidently, because they were larger, the animals of the control lot of the brood of 1919 also produced eggs a year earlier than the hybrids of the same age. Eggs generally are not produced, regardless of age, until at least some of the females have reached a length of about 135 millimeters (5½ inches), although a few smaller females among the older animals have laid eggs.

It is not possible to make a fair comparison between the fecundity of the hybrids and straight Carolina stock, because it is not known exactly how many females of each lot produced eggs. Furthermore, an unknown number of eggs prior to 1930 was destroyed by rats, and in 1930 most of the eggs produced by the hybrids of the brood of 1919 were used in embryological studies by another investigator. However, the indications are that fecundity in hybrids may be about equal to that of pure bred Carolina terrapins. In spite of the preponderance of males among the hybrids, the eggs were not all fertile. Each year a small proportion of the eggs remained in the beds until the end of the incubation period and did not hatch.

The eggs of the hybrids of the brood of 1920 were less disturbed by rats and only 40 were used in the embryological study. Therefore, the data on the fertility of the eggs of this lot appear to be of some interest. In 1928 this lot (consisting of 35 males and 21 females) produced 28 eggs of which 27 hatched; in 1929 138 eggs were laid (104 hatched); and in 1930 a total of 171 eggs were laid (in addition to the 40 removed during the incubation period), of which 145 hatched. This amounts to a combined fertility for the three seasons of 81.9 per cent.

Owing to destruction of eggs by rats and also by a storm (in 1929) a fair comparison can not be made in regard to fertility of eggs produced by the control lot of Carolina terrapins of the same age. However, a comparison of the fertility of the eggs of the control

lot of Carolina terrapins of the brood of 1919 appears to be of some interest. This lot (consisting of 27 males and 46 females) produced 123 eggs in 1928 (105 hatched); 116 in 1929 (99 hatched); and 327 in 1930 (322 hatched), making a combined fertility for the three seasons of 92.9 per cent. Therefore, the Carolina lot with fewer males produced a higher percentage of fertile eggs than the hybrid lot with more numerous males.

Great fluctuations in the percentage of fertile eggs have been noted by the present writer[2] (pp. 32-36 and Tables 6 to 14), sometimes (over a series of years) even within one lot. Therefore, the data here presented may not be particularly significant. They do show, however, that regardless of the preponderance of males among the hybrids, a considerable number of eggs failed to hatch. A hatch of 81.9 per cent of the eggs, lower than in the control lot of the 1919 brood, must be regarded as fair when compared with the general results for all lots of terrapins grown in captivity. While the eggs that failed to hatch were not all opened for examination, those that were examined gave no indication of any development. This has been so usual in eggs examined over a period of years that the ones failing to hatch may be regarded as infertile.

In the light of the foregoing data, it is evident that, while the hybrids resulting from Texas and Carolina terrapins (both crosses) are fertile, it can not be said that they are either more or less prolific than the straight Carolina terrapins. Furthermore, the percentage of the eggs produced by the hybrids that hatched regardless of the preponderance of males, was not significantly higher or lower than among many lots of Carolina terrapins.

Conclusion

No advantages from a practical standpoint were secured by hybridizing Texas and Carolina diamond-back terrapins. On the other hand, some disadvantages are indicated, namely, slow growth and late maturity, and a preponderance of males, which do not grow nearly as large as females and have much less value on the market. The quality and flavor of the meat of the hybrids was not tested.

TABLE I.—Rate of growth of hybrid terrapins of 1919 brood; two lots.

When Measured	Texas males x Carolina females					Carolina males x Texas females				
	No.	Smallest mm.	Largest mm.	Females 125 mm. in length or over	Aver. mm.	No.	Smallest mm.	Largest mm.	Females 125 mm. in length or over	Aver. mm.
5-18-20	25	25	32	-	30.7	100	29	42	-	33.3
9-24-21	24[1]	32	90	-	63.0	30[2]	43	93	-	68.3
9-14-22	23	42	107	-	78.0	31	41[1]	95[1]	-	66.3
9-10-23	24[1]	55	120	-	86.1	31	65	119	-	83.1
10-7-24	23	68[1]	134	-	97.8	31	74	127	6	92.6
10-22-25	23	61	135	3	95.5	30	78[1]	150	1	94.2
10-22-26	21	76	144	7	98.3	30	78	145	4	108.6
9-20-27:										
Males	13[1]	86	104	10	93.3	10[1]	81	106	0	91.6
Females	19	91[1]	148		125.2	15	96	150		127.0
11-16-28										
Males	18	82	104	14	97.5	20[1]	80[1]	110	0	99.6
Females	20	99	158		131.9	18	99	154		131.1
10-23-29										
Males	30[1]	86	106	17	99.5	21	81	111	0	100.4
Females	21	115	157		137.6	11	110	153		130.9

TABLE II.—Rate of growth of Carolina terrapins of the 1919 brood.

When Measured	Offspring of domestic stock				
	No.	Smallest mm.	Largest mm.	Females 125 mm. in length and over	Average mm.
5-13-20	100	28	48	-	40.2
9-20-21	90	41	92	-	68.0
9-19-22	67	44	120	-	77.4
10-10-23	61	58	117	-	87.6
10-8-24	79	68	123	-	90.0
10-27-25	78	75	132	4	95.2
10-8-26	70	75	139	14	104.7
9-20-27:					
Males	22	76	98	26	90.4
Females	36	87	164		119.3
11-4-28:					
Males	26	86	124	37	98.0
Females	40	109	167		131.5
10-22-29:					
Males	24	86	125	43	93.5
Females	44	119	149		133.5

TABLE III.—Rate of growth of hybrid terrapins (Carolina males and Texas females) of the 1920 brood.

When Measured	Number	Smallest mm.	Largest mm.	Females 125 mm. and over in length	Average mm.
6-23-21	27	25	30	-	28.5
10-3-21	43	31	88	-	43.4
9-14-22	47	41	86	-	62.6
10-5-23	44	55	115	-	79.2
10-18-24	44	55	115	-	84.6
10-22-25	43	65	131	-	93.1
9-30-26	43	82	135	9	105.0
10-3-27:					
Males	42	86	109	10	94.4
Females	50	108	146		120.2
11-12-28:					
Males	34	88	117	19	100.0
Females	51	110	157		141.0
10-24-29:					
Males	23	89	116	20	103.7
Females	51	120	164		140.4

TABLE IV.—Rate of growth of Carolina terrapins of the 1920 brood.

When Measured	Number	Smallest mm.	Largest mm.	Females 125 mm. and over in length	Average mm.
6-1-21	50	23	43	-	37.5
9-24-21	50	45	85	-	59.6
9-16-22	-	-	-	-	-
10-10-23	39	60	105	-	83.6
10-11-24	31	76	108	-	91.1
10-22-25	-	-	-	-	-
10-1-26	28	75	120	4	102.0
9-20-27:					
Males	-	-	-	-	-
Females	33	90	136	6	116.9
11-16-28:					
Males	-	-	-	-	-
Females	24	99	144	11	122.8
10-23-29:					
Males	-	-	-	-	-
Females	26	110	149	22	134.3

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Books Received

***BOOKS** are acknowledged in this column as received, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the reader of the* JOURNAL *will be reviewed in later numbers.*

CATTLE FARMING IN SOUTH AFRICA, *by* A. M. BOSMAN, Prof. of Animal Husbandry, University of Pretoria. 458 Pages. Illustrated. The Central News Agency, Itd., P. O. Box 1033, Johannesburg. 27 Shillings 6 pence.

THE PLANT WORLD IN FLORIDA, From the Published Manuscripts of DR. HENRY NEHRLING, Collected and Edited by Alfred and Elizabeth Kay. Sponsored by The Garden Club of Palm Beach. 22 Chapters, 27 illus., $3.50. The Macmillan Company, New York, 1933.

THE FIRST TWO YEARS, A Study of Twenty-Five Babies, Vol. II Intellectual Development, *by* MARY M. SHIRLEY, Asst. Prof. of Psychology, Randolph-Macon Woman's College. 513 Pages. $3.00. Illustrated. The University of Minnesota Press, Minneapolis.

IN PLACE OF PROFIT, *by* HARRY F. WARD. Social Incentives in the Soviet Union with Drawings by Lynd Ward. Five Parts. Seventeen Chapters. 460 Pages. $2.50. Charles Scribners Sons, New York, 1933.

What makes the Soviets go round.

POPULATION TRENDS IN THE UNITED STATES, Recent Social Trends Monographs, *by* WARREN S. THOMPSON, Director of the Scripps Foundation for Research in Population Problems and P. K. Whelpton, Scripps Foundation for Research in Population Problems. Eleven Chapters. Appendix, Tables, Index. 415 Pages. McGraw-Hill Book Co. 1933. Price $4.00.

RURAL SOCIAL TRENDS, Recent Social Trends Monographs *by* EDMUND DE S. BRUNNER, Director of Town and Country Survey Series, Institute of Social and Religious Research, and Professor of Education, Teachers College, Columbia University; and J. H. KOLB, Professor of Rural Sociology, College of Agriculture, Univ. of Wisconsin. Twelve Chapters, Seven Appendices, Index. Mc-Graw-Hill Co. 1933. Price $4.00.

SO THIS IS SCIENCE! *by* H. F. ELLIS (Egregious Professor of all the Sciences at the Universities of Oxford and Cambridge). Illustrated by Arthur Watts. 109 Pages. E. P. Dutton & Co., Inc. 1933. Price $1.75.

Parodies of scientific verbiage must pay: they keep on issuing from the presses.

CRIMES AND CRIMINALS, *by* WILLIAM A. WHITE, A. M., M. D., Sc. D. Fourteen Chapters. 276 Pages. Farrar & Rinehart, Inc., Publishers. Price $2.50.

SCIENTIFIC THEORY AND RELIGION, *by* ERNEST W. BARNES, Sc. D., Hon. D. D., Hon. LL. D., F. R. S., Bishop of Birmingham. Pages xxiv-685. Price $4. The Macmillan Company, New York, 1933.

Bishop "Soapy Sam" Wilberforce died in 1873.—surviving his famous collision with Huxley some thirteen years. In the intervening three-score years bishops have metamorphosed indeed. The present Bishop of Winchester is intimately acquainted with science on most of its multitudenous fronts, and discusses the concepts of both Mendel and Einstein and their followers at great length, and finds a place in modern theology for the views of both.

A TEXTBOOK OF GENERAL BIOLOGY, *by* E. GRACE WHITE, Ph. D., Pro-

fessor of Biology at Wilson College. Pages 615. Illustrations 295. Price $3. The C. V. Mosby Company, St. Louis, 1933.

THE HEROIC AGE OF SCIENCE, *by* WILLIAM ARTHUR HEIDEL, Research Professor of the Greek Language and Literature at Wesleyan University, Research Associate of the American Council of Learned Societies and of the Carnegie Instituiton of Washington. Pages 203. Price $2.50. The Williams Wilkins Company, Baltimore, 1933.

Greek is the word for it.

SEX DETERMINATION, *by* F. A. E. CREW, M. D., D. Sc., Professor of Animal Genetics in the University of Edinburgh. Pages 138. Price 3s. Methuen & Co., Ltd., London, 1933.

PREPARATION FOR MARRIAGE, Edited by KENNETH M. WALKER, F. B. C. S. Introduction by Logan Clendening, M. D. 175 Pages. Twelve Chapters. Glossary. Index. W. W. Norton & Co. Price $2.00.

THE SCIENCE OF HUMAN REPRODUCTION, *by* H. M. PARSHLEY, Sc. D., Professor of Zoology at Smith College. Pages 316. Illustrations 66. Price $3.50. W. W. Norton, New York, 1933.

One gathers from the number of publications on this subject that these times may come to be known as the "Heroic Age of the Science of Human Reproduction."

A BIBLIOGRAPHY OF DIFFERENTIAL FERTILITY, edited by ELDON MOORE on behalf of Commission II of the International Union for the Scientific Investigation of Population Problems. Pages 97. Price 2 Shillings. Garden City Press, Edinburgh, 1933.

From Malthus to Moley (or hasn't the Brain Trust yet told General Johnson to draw up a code for expectant parents? Suggested emblem: infants rampant on field of parents azure dodging bill- and tax-collectors.

THE APE AND THE CHILD, *by* W. N. KELLOG, Associate Professor of Psychology, Indiana University and L. A. KELLOG. Pages 341. Illustrations 80. Price $3. McGraw-Hill, New York, 1933.

Rather hard on the Unique Educability of the young of H. Sapiens.

INTELLECTUAL CRIME, *by* JANET CHANCE. Pages 154. Price $5s. Noel Douglas, London, 1933.

Quick, Johnson, a code!

Fischer on Race Crossing

Prof. Eugen Fischer, an authority on anthropology, recently lectured on "The Crossing of Different Races, in Relation to Intellectual Performance." The crossing of different races, of all biologic processes, has the most far-reaching results for the general development of mankind. It is not of such importance to inquire what the results are of a crossing of two individuals belonging to different races. The old conception that was widely accepted that crossbred individuals always present the defects of both parents is fundamentally false. The crossbred individuals that originally gave rise to this belief sprang from haphazard, illegitimate relations between white men and women of the colored races. Quite generally, such persons are despised and rejected by both races represented by their parents. Much greater importance attaches to the crossing of whole groups belonging to different races. The most extensive crossing of races known in Europe took place during the so-called migration of the nations, when large groups of Nordic races crossed with peoples of other European races (Alpine, Dinaric, Mediterranean, antero-Asiatic). Through the mingling of these races of equal intellectual caliber, the present-day high civilizations arose. In regions where the Nordic race is purest, it has not achieved any conspicuous cultural greatness. The highest attainments have been secured in the area in which crossing occurred. Here, for instance, the German people produced most of its musicians, poets and thinkers. Northern Europe, on the other hand, where almost pure Nordic elements are still found, has produced great statesmen, generals and organizers in commerce and industry.

The "laws" governing hereditary physical characteristics are not so difficult to discover, but the "laws" affecting hereditary mental qualities must be deduced. There is no doubt that these, as well as the former, follow the well known mendelian "laws." It is a fact that in especially fortunate crossings the crossbred individuals have qualities that excel, by far, those of their parents. In other words, they "luxuriate," and all breeding of animals and plants is based on this capacity. Judging from the results of racial crossings, not only in Eurore but also among the Japanese, it appears as if such an exuberant development of the mental qualities intelligence, temperament, disposition and character constituted the fundamental basis of European progress, after the completion of the migration of the nations.—"Berlin Letter," *Journal* of American Medical Association, March 13, 1933.

VARIATIONS IN FUSED FINGERS

Figure 8

Hands and feet of three individuals in the fifth generation (Figure 9) are shown: *A*, hands of *V-14; B* and *C* hands and feet of *V-13; D*, hand of *V-12*. Most of the syndactyl individuals in this family show a mild form of the character, such as that shown at *A* above.

SYNDACTYLISM WITH VARIATIONS

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State Teachers' College, Cedar Falls, Iowa

THE history of the family involved in this report is known since 1860. There have been five generations and a total of one hundred and six individuals; seventeen of these have had a deformity in either hands or feet or in both hands and feet. Two members of the family, *V-17* and *18*, have not been studied.

The husbands in the first and second generation had twin toes according to reports of the wife of *II-2*. All other cases have been observed or reported by close relatives who are well known to the author.

This has been a normal, average family with the exception of this defect in hands and feet. Its mentality has been average or above. *III-4* was a successful physician, while others have been farmers and day laborers. Two cases of insanity have occurred in the immediate family of *III-3*, namely the wife and daughter (*IV-8*). The morality of the family has been average. There have been no known cases of gonorrhea or syphilis. The members as a whole have been sober and law abiding.

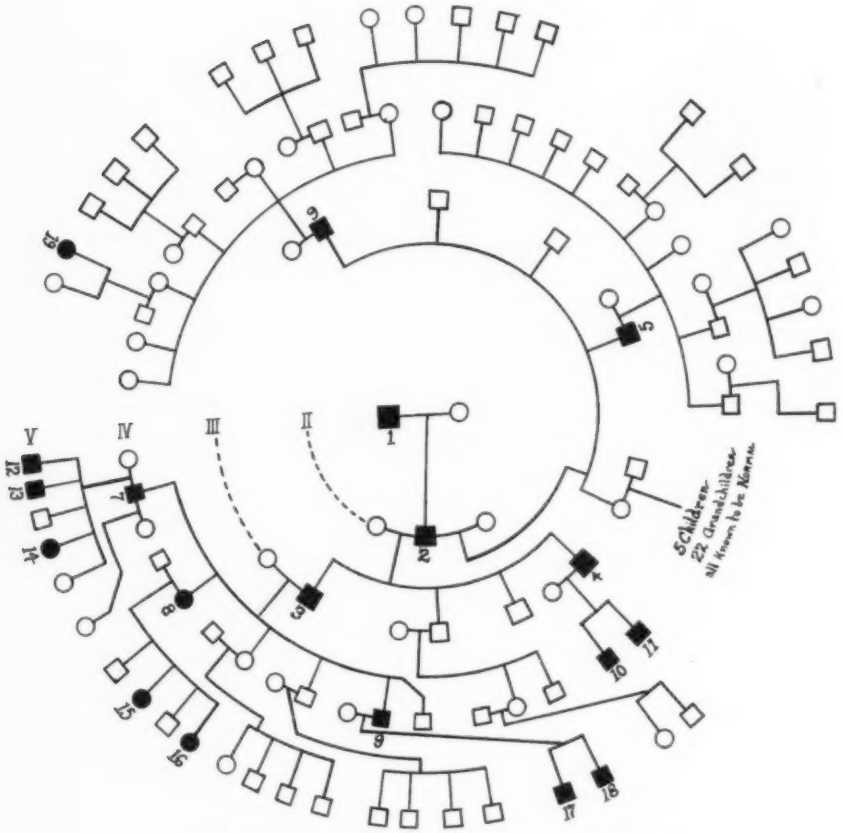
This account has been given because Edwards[1] and Murphy[2] suggest that low mentality, alcoholism, and inbreeding have been responsible for syndactylism in the cases which they reported. Low mentality and alcoholism may accompany syndactylism but it is difficult to see any causal relation.

The nature of the deformity in the family involved in this report has been variable. However, a simple web has been the prevailing type. This defect has occurred in either hands or feet or in both, in the same individual. The web is either partial or complete. Figure 8, *A* shows a typical case. *I-1*, *II-2*, *III-3*, *4*, and *6*, *IV-7*, *8*, *V-14*, *V-19* have this simple twinning either in fingers or toes. *IV-7*, in addition to the web, has an extra small but complete toe, while his daughter, (*V-14*), has but three fingers and a thumb on one hand (Figure 8, *A*). All other cases have been more serious. The forefinger and thumb of *III-5* are grown together. All others having the deformity show defects something like *V-13*, whose hands and feet are shown in Figure 8, *B* and *C*. Figure 8, *D* shows the right hand of *V-12*. The left hand is similar. The feet in this case are similar to those in Figure 8, *C*.

When simple webbing occurs, the digits are complete and nails are present. In the more serious cases the bones are usually distinct though definitely tied in with other bones and are apparently controlled by the same muscle or group of muscles. There may or may not be a full set of nails; usually some of the nails are absent.

II-2 married twice and of his nine children, four had twin toes or twin fingers. *III-4* had two children, both of whom had a deformity in hands and feet. *II-3* had six children, three of whom had a deformity. *III-5* had nine children none of whom carried any deformity. *III-6* had seven children none of whom had the mark, though it appeared in a granddaughter, *V-19*. *IV-9* had two children but failed after several requests to give information concerning the extent of the defects. *IV-8* had four children, two of whom are seriously deformed in both hands and feet. *IV-7* was married twice and had six children, three of whom have deformities of variable nature.

Only in one case has the defect occurred unless it was in the immediate parent. All the affected parents, *III-5* and *III-6* excepted, passed this mark on to approximately one-half of their children. It looks as if the defect is a dominant one and the carriers are



FIVE GENERATIONS OF FUSED FINGERS

Figure 9

In this family various degrees of syndactyly have been directly inherited (with one exception) for five generations. The character has been extremely variable, in some individuals only a webbing between two fingers has been manifest. In the extreme form four of the fingers are fused (see text and Figure 8). The variations in degree of syndactyly and the skipped generation in inheritance in the fourth generation (see *V-19*) suggest that a principal gene and a modifying factor or factors are involved. The earlier generations of the pedigree trace to a family living in central Tennessee. The individuals who contributed the information which made this study possible live in Illinois.

heterozygous for the factor. However, it is difficult to see how the sixteen children of *III-5* and *III-6* failed to show the deformity. The case is further confused by the appearance of the mark in the fifth generation after it has been entirely absent in the fourth generation as in the case of *V-19*.

It is evident that the deformity involves more than simple syndactylism and that dominance is not clear cut. Other factors must be involved.

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Other Pedigrees of Syndactyly and "Lobster Claw"

THE other articles on the inheritance of syndactyly which deserve mention in The Journal are of interest in connection with the preceding article. These appear in the *Annals of Eugenics* for May, 1931 (Vol. IV, parts III and IV, Cambridge University Press, England). In this publication Julia Bell gives three pedigrees of families showing various degrees of syndactyly (fused fingers). In one family the fifth finger was bent inward and fused to the tip of the fourth finger. This appears to be a dominant character. In another family short fingered hands in which the third and fourth fingers were fused showed no direct inheritance for three generations. In the third family direct inheritance for five generations indicates a dominant character. The article is illustrated with excellent photographs and X-rays of some of the affected hands.

In the same publication Prof. Karl Pearson records the existence in apes and monkeys of the extreme form of syndactyly called "lobster claw" (see Figure 8*B* in the article by Dr. Scott). The extreme expression is characterized by the absence of all the fingers except the little finger, which is bent inward across the region where the missing fingers would have been situated. The case reported by Pearson in a macaque monkey shows a syndactylism of the third and fourth fingers. These present an appearance not unlike the "mild cases" shown in the preceding article (Figure 8*A*). X-ray photographs are shown of these anthropoid "lobster claws" and of human "lobster claws" for comparison. The condition is also reported in the hand of a young chimpanzee.

Pearson believes that the existence of this defect in the anthropoids and in the old world monkeys proves that it has a long evolutionary history. This would imply a genetic relationship between the syndactyl genes in these distinct genera. If these mutations had shown survival value, it is likely that the character would have become fixed in some branch of the anthropoids. Since the variation has not encountered conditions which have conferred definite benefits on either "clawed" men or monkeys, it appears to have been carried along in a few lines without being multiplied to any great extent. In the human species under modern conditions "claw fingers" doubtless have a greater survival value than at any other time in their history. Under primitive conditions where any marked deviations from the normal appear to have been very unsympathetically dealt with, claw fingers would be less likely to be perpetuated than under modern conditions where all life is considered sacred. In a culture in which philanthropy and welfare work are administered on a purely emotional basis we might even imagine a situation in which disabling defects might confer on their possessers an actually increased chance of passing on such defects as compared with the normal.

It is interesting to speculate on how the character has been perpetuated in such widely separated groups as the homidae, the anthropoids, and the simiadae under conditions unfavorable to its survival. If we assume with Pearson that these conditions are related, an answer is perhaps to be found in the wide variations which the character shows in most of the families in which it appears. In the family described by Scott, the character varies all the way from a web between two fingers at

their base to a complete lobster claw. In other words, the character varies from virtual recessiveness to complete dominance. It is possible we have here another instance of the development of dominance through modifying factors, as postulated by Fisher. Landauer has reported recently in this Journal, such a modifying gene that changes the frizzling gene in the fowl from a dominant virtually to a recessive. It is conceivable that such a mechanism accounts for the extreme variation in the finger abnomality observed in many of these pedigrees. If we adopt Pearson's view we may conceive of a rather widespread "lobster claw gene" which is normally completely recessive. In certain families we have modifying factors brought together that bring this fundamental gene to light. We can conceive of the extreme condition representing the homozygous state of the modifying factor and the intermediate condition as the heterozygous state. If we want to speculate further we can postulate two modifying factors, both of which are necessary to produce the extreme "lobster claw" form. This gives us several possible combinations of the two factors to account for the several grades of syndactyly. According to such a view we would get the extreme grades of syndactyly inherited as a dominant character only when two individuals happen to marry who are homozygous for complementary factors. This, of course, would be a rare occurrence, but syndactyly is a very rare condition. One or two such hypothetical "modifiers of dominance" appear to account very well for the observed facts.

If the preceding speculations have any value it would be in suggesting new approaches to this problem. The "modifiers of dominance" view may enable us to understand how a character of negative survival value may appear as a dominant or partial dominant in cousin phyla, and be actually related. Any such relationship between lobster claw genes in men and macaques would hardly be possible if such a character were expressed in each generation as would be the case in dominant inheritence. We can picture such a gene lying dormant in the germ plasm for ages even, awaiting the chance concatenation of the right modifying factors in the gene-strings of the chromosomes.

R. C.

Legal Aspects of Sterilization

HUMAN STERILIZATION, *by* J. H. LANDMAN. Pp. xviii, 341. Price $4. The Macmillan Co., New York. 1932.

DR. LANDMAN surveys the history of the eugenics movement, the need of negative eugenics, the inheritance of human defects, the nature of the sterilization operations, the administration and the legal history of the sterilization laws. As a jurist he is particularly concerned with the phase last named, on which his details are of most value. The sections dealing with biology are not satisfactory, but the book is a convenient work of reference with extensive appendices and bibliographies. The most important development since the book was published is the decision of the supreme court of North Carolina, holding invalid, on technical grounds, the sterilization law of that state. This reduces to 26 the number of states that have laws actually in force. Statistics of later date than those given by Dr. Landman indicate that at least 16,000 sterilizations have been performed under these laws. Since the first official sterilizations date from 1899, it is evident that eugenic sterilization in America is well past the experimental stage. Most of those who are really familiar with the subject regard it as one of the indispensable elements in any broad, well-balanced, and far-sighted program for dealing with the handicapped members of society.

PAUL POPENOE.

INHERITANCE OF A WHITE STAR IN THE DEER MOUSE

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A STAR or blaze on the head is a common form of white spotting in many orders of mammals. Its frequent position here, on the mid-dorsal line, may have some developmental significance.[5] Little[6, 7] has found that a white blaze is inherited as a multiple gene character in the house mouse. His figures[7] show the blaze between the eyes or extending from this point toward the pinnae. Dunn[2] and Dunn and Durham[3] have reported a modification of the recessive piebald pattern in *Mus* which varies in its expression from a small blaze to a wholly white face. This character acts as a dominant when piebald spotting is present.

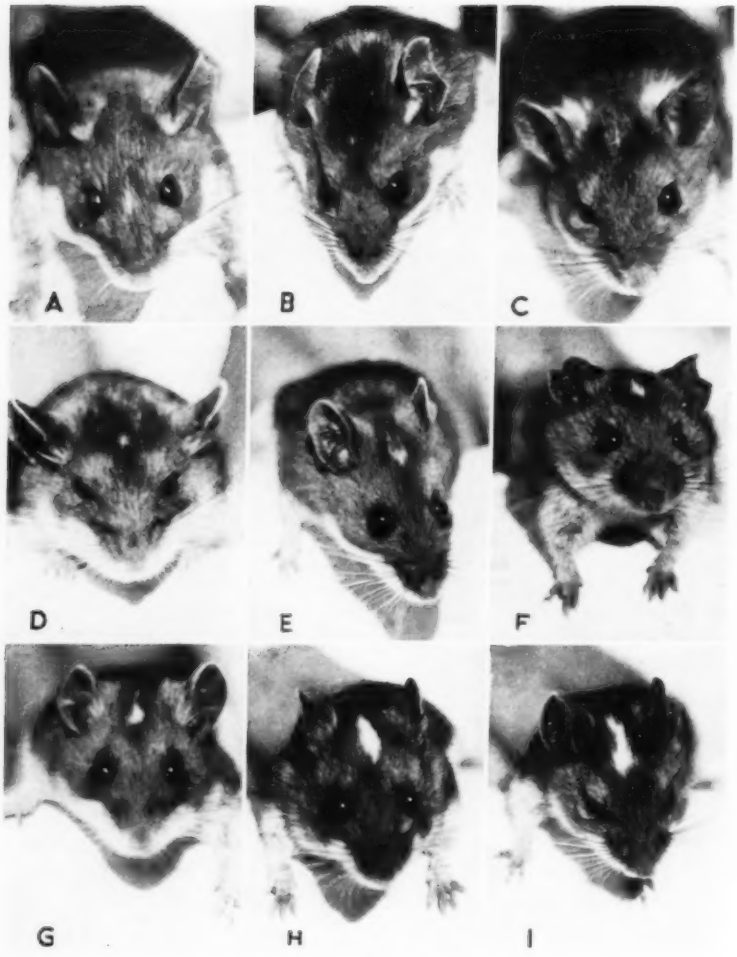
White spotting has not been investigated so thoroughly in *Peromyscus* as in *Mus*. Castle and Phillips report having developed spotting in *Peromyscus leucopus* by means of selection. Feldman and Dice[4] list a recessive type of spotting in *Peromyscus maniculatus rufinus* and a dominant type in the subspecies *beardii*. Sumner[8] states that stars have been observed in various races of *Peromyscus* but that the method of their inheritance has not been analyzed. The present writers have found stars, either on the nose or forehead, in three per cent of 1085 wild specimens of *Peromyscus maniculatus* taken in Oregon. The appearance of similar spots in cage-born mice prompted the genetic study of this character.

The star consists of a patch of hairs, white to the base, on or near the mid-dorsal line of the body and is usually found about half way between the eyes and the pinnae. Large stars in *Peromyscus* frequently extend well back between the pinnae, and stars have been less frequently observed on the snout or between the eyes in the position figured by Little for the blaze in *Mus*. One mouse in our stock has both a star between the eyes and one on the forehead.

The size of the stars observed varies from a few white hairs to a patch one and one-half centimeters long. In shape the stars vary from a circular patch to a longitudinal streak, which may be discontinuous. In wild mice and in cage-born young from random matings the size of the star is inversely proportional to the frequence of its occurrence. Figure 10 illustrates the common positions for stars and the variability and extension of the character in our stock.

Large stars may be seen as soon as the skin becomes pigmented and remain observable throughout life. Tiny stars, of a few white hairs, may be seen in adults on which no stars were observed in early pelages. Occasionally a star observed in an individual is not found at a later examination. This may be due to the fact that lost hairs are not immediately regenerated, and possibly to a greater tendency on the part of unpigmented hairs to be lost. For analytical purposes a mouse exhibiting a star large enough to be seen with the naked eye at any time has been considered to be a starred mouse.

Two subspecies of *Peromyscus maniculatus*, *gambeli* and *rubidus*, as well as hybrids of these two races have been used in producing data upon the inheritance of this character. In an endeavor to avoid great differences in nutritional conditions it was the practice to reduce all litters to a maximum of four within a few days of birth. The remaining mice were examined at the age of one month or more for the purpose of recording the presence or absence of stars. These records were checked by subsequent examinations at irregular intervals. Mice which were killed or lost before they were four weeks old and on which no star was seen have been recorded as "doubtful"



STARRED DEER-MICE

Figure 10

Variations in size, shape, and position of stars in *Peromyscus maniculatus*. *E* and *G* are *gambeli* stock and show the largest stars observed in wild and cage-born mice respectively in this race. The others are hybrids between *gambeli* and *rubidus*. *H* and *I* show the largest stars obtained from non-starred and starred parentage respectively. In addition to the star *I* had a white spot on the ventral surface and on the dorsal tail stripe.

rather than as "non-starred" since stars might have appeared in later pelages had the mice been kept. So far, seven per cent of 242 mice which were first recorded as non-starred were later recorded as starred, and this percentage may later be somewhat increased.

The frequent appearance of starred mice in litters in which neither parent was starred suggested to us at first that a pair of recessive genes is essential for the production of this character. Using this as a postulate, heterozygous stars would include (1) all non-starred mice which have produced starred offspring and (2) all non-starred mice which have not yet produced starred young but which have one starred parent. All mice with visible stars would be considered homozygous for the character.

The results of matings in which mice of the above-mentioned types were used as parents are as shown in Table I.*

In each of these three kinds of matings the number of starred young obtained is less than the number expected for a single gene recessive character even if every allowance is made for the development of the character in young non-starred mice. The fact that starred mice mated *inter se* throw a large percentage of non-starred young is especially difficult to harmonize with the hypothesis unless non-genetic variations of the character greatly overlap the genetically non-starred condition.

An alternative hypothesis would be the interaction of multiple genes some of which increase and others decrease the number of white hairs in a definitely localized region. Such an hypothesis fits our results fairly well for, in general, the larger the area of white in parent mice, the larger the average size of stars in the young and the more young there are with stars. For example, when *Peromyscus* are grouped according to the size of their stars the results of matings in which both parents are starred as shown in Table II.†

As would be expected for a multiple gene character, much larger stars have appeared among our selected cage-born mice than any which have been seen in trapped specimens. There is some indication that the shape of the star also is inherited.

A white ventral spot is present in 14 ± .84 per cent of the starred mice. Ventral spots, although also seen on non-starred mice, occur with star somewhat more frequently than would be expected by chance. This may indicate that linkage occurs between genes for star and ventral spot or that both characters are dependent upon certain of the genes in the star complex. Little observed the association of a ventral spot with the blaze in *Mus*. This is another instance of the similarity of the genetics of a similar character in these two genera.

Summary

1. Stars have been found in three per cent of 1085 wild specimens of *Peromyscus* trapped in Oregon.

2. Matings between starred mice as well as matings between non-starred

*TABLE I.—Results of Matings of Heterozygous Mice.

Mating	Offspring — Starred	Non-starred	Doubtful
Heterozygous star × heterozygous star	35	135	10
Expected‡	42	127	
Homozygous star × heterozygous star	55	65	10
Expected	60	60	
Homozygous star × homozygous star	91	33	9
Expected	124	0	

‡ The "doubtful" mice have been ignored in calculating the expected number of starred and non-starred young.

† TABLE II.—Parents Grouped According to Size of Star.

Mating	Offspring — Starred	Non-starred	Doubtful
Both parents having small stars	13	12	4
One or both parents having a large star	78	21	5

mice may produce both starred and non-starred offspring.

3. The larger the stars of parent mice the more young they get with stars and the larger the average size of the stars of the young.

4. A white ventral spot is found in starred mice somewhat more often than would be expected by chance association.

5. The above observations point to an inheritance involving multiple genes.

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Psychic Factors in Development

WOLTERECK, R., GRUNDZUGE EINER ALLGEMEINEN BIOLOGIE (Outlines of a general biology). XVI, 629 pages; 271 figures in the text. Paper covers 40 marks, cloth 43 marks. Ferdinand Enke, Stuttgart, 1932.

WOLTERECK, whose name is well known to geneticists from his important studies with Daphnia, presents in this book an attempt to outline the general categories and principles of biological facts and events. In the introductory part Woltereck discusses the philosophical and psychological foundations of biological research. The second part deals with all the different morphological and physiological properties of living organisms. This presentation is especially interesting on account of the fact that the main emphasis is placed on the relation of structure to function. The third part is devoted to the psychic qualities of living organisms and the importance of psychic processes for developmental and physiological processes. The chief aim of the book is to trace those fundamental principles which are characteristic of life as compared with inorganic nature.

The principal conclusion at which Woltereck arrives in his discussion is that organisms are not only morphological structures and functioning machines of a mechanistic nature but in addition are living systems with psychic reactions of their own. There is little doubt that many of Woltereck's conclusions will not be accepted by biologists. On the other hand, it seems certain that at present nothing is more necessary for the progress of biological research than attempts to define the foundations of our biological knowledge. Woltereck's book is a serious contribution of this nature and for this reason deserves the attention of all biologists. It must be added, however, that on account of many (perhaps unnecessarily many) new technical terms which the author introduces the book is difficult to read for those who are not thoroughly familiar with the German language.

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TEN YEARS OF SEX RESEARCH

A Review

SEX AND INTERNAL SECRETIONS: A Survey of Recent Research. *Edited by* EDGAR ALLEN. Issued under the auspices of the Division of Medical Sciences of the National Research Council. Pp. 951. $10.00. Published by The Williams & Wilkins Company, Baltimore, U. S. A. 1932.

THERE was a time, and not so very long ago, when the literature relating to sex was largely pornographic; social and other considerations made it a subject not fit for serious study by the biologist. But more recently, thanks to the activities and character of certain men, we have been taught through science that in all probability all expressions of sex are nothing more or less than the results of the workings of a knowable, chemical mechanism. Sex is no longer one of the great mysteries that defy understanding. Its implications and repercussions merely stimulate enquiry. Sex is no longer a thing to be feared; it has become a fit and proper subject to be examined and explained. Because of the terrible harm that our ignorance of sex has caused, it must be understood and thus directed and controlled.

During the last ten years or so the workers in the field of sex and reproduction have been extraordinarily active, and discoveries have been many. American biologists, it is interesting and significant to note, have taken the lead in these investigations, and their success is generally and generously recognized. Without doubt, one contributory factor largely responsible for the fact that so much first-class work has been carried out in America was the creation of the Committee for Research in Problems of Sex. This Committee, ten years ago, initiated a program of research on the fundamental problems of sex, and, as its tenth anniversary approached, it took stock of what had been done under its auspices. It was decided that a book should be published, with Professor Edgar Allen as its Editor, which should survey the most important recent researches in problems of sex and especially those concerned with internal secretions, in order that the concepts already established by experimental evidence might be clearly stated and made readily available. The book was to be addressed to the reader with a moderate biological background, to whom the less involved technical terminology might not prove a serious handicap. It was not to be, by any means, a popular book on sex. Indeed, it was to be designed deliberately for those interested in the progress of research in problems of sex, and for those who were actually engaged in investigation thereon.

The book as issued is indeed a monument to the vision and enterprise of the Bureau of Social Hygiene, to the wisdom of the Committee for Research in Problems of Sex, and to the devotion and ability of its Secretary, Mr. Earl F. Zinn.

The Editor, recognizing that specialization in research has reached the point where any detailed and authoritative survey of a whole subject cannot possibly be undertaken adequately by any single individual, gathered together a group of 22 investigators whose work has established them in their respective fields, and to each of them he allotted a chapter. Each of these contributors has developed his chapter in his own way. Many of them, but by no means all, accomplished their work under grants received from the Committee for Research in Problems of Sex. The list of contributors is imposing. The names are in themselves a reliable indication of the value of the book which is so extraordinarily rich in its presentation of detail that any short review must necessarily fail. Such can neither do justice to the wealth of detail nor deal with the general theme, since, as might have been ex-

pected, no one point of view regarding the general problems of sex is common to all the contributors.

Everyone, no matter what his particular interest in the biology of sex may be, will find in this book a chapter addressed especially to himself. If the reviewer picks on one chapter rather than another, it is simply an indication of his own particular interests.

Professor C. H. Danforth, in his chapter which deals with the interrelation of genic and endocrine factors, reviews in admirable fashion the various theories concerned with the nature of and the mode of action of the sex genes. A proposed modification of the theory of "Alternative Relationsnorm" is of particular interest. The discussion of the rôle of endocrine factors in intersexuality is based mainly on Goldschmidt's methodological approach, but the factual material includes the results of recent investigations on the development of the plumage of the fowl.

Dr. Calvin Bridges writes a most lucid chapter on the genetics of sex in *Drosophila*. As would have been expected, he tells all there is so far to tell in a manner that would persuade those that do not know its difficulties that *Drosophila* is the very simplest and the most convenient of experimental material.

Professor Witschi reviews the field of sex deviations, inversions, and parabiosis. He employs general biological notions in his discussion of sex differentiation and regards the cortex and medulla of the gonad as the indicators of female and male differentiation respectively. His contribution is of outstanding interest, and together with that of Danforth constitutes a most welcome development in physiological genetics.

Sex Hormones

Professor Carl Moore deals with the biology of the testis, reviewing briefly the experiments which have established the endocrine function of the testis and its biological rôle. He presents his own theory pertaining to the so-called sex hormone antagonism, and maintains that the secretion of either gonad suppresses the gonadotropic action of the anterior lobe of the pituitary and thus leads to a suppression of gonadic activity and to the subsequent involution of the characters dependent upon the gonadic hormones. One might suggest that this part of his contribution would have been more satisfactory if the divergent findings such as those of Allanson and of Lacqueur had been considered in the appropriate context. Moore's contribution is notable for the review that it gives of the various indicators of the sex hormones.

Professor Koch's chapter on the chemistry and assay of the testis hormones is somewhat disappointing in that the author, who was primarily responsible for the preparation of an active testicular extract, tells us very little of his own experience and restricts himself to a very brief review of data published by authors of widely differing reliability and originality. Modesty of this kind is no doubt admirable, but it can be irritating.

Professor Edgar Allen reviews the biology of the ovarian follicular hormone. His chapter is one of the most informative in the whole book and constitutes a review which possesses the merits of briefness and adequacy.

Professor Doisy contributes a most welcome chapter on the chemistry of the follicular hormone, and this section constitutes the first comprehensive survey of the known methods of preparation. Surely Professor Doisy is mistaken when he refers to his communication to the 13th International Physiological Congress on the isolation of the crystalline follicular hormone and mentions in the same paragraph that Lacqueur succeeded in obtaining the crystalline hormone "still later" (that is later than Butenandt). Is it not the case that Lacqueur referred to his own results at the same meeting at which Professor Doisy spoke?

Professor Hisaw deals with the

physiology of the corpus luteum and concludes that this structure, particularly in the case of the sow, secretes at least two characteristic hormones, one producing progestational proliferation and another which is responsible for the relaxation of the pubic ligaments. One is left to wonder if Professor Hisaw has fully recognized the importance of variations in the concentration of theelin in such experiments involving the use of corpus luteum extracts, and his presentation of the facts is perhaps inclined to obscure the distinctly problematical nature of many current conclusions.

So one could pass from chapter to chapter, pausing continually to praise, for everywhere praise would far outweigh any attempt at helpful criticism. But apart from any question of detail much might be said of the general impression which the reader receives as he turns with increasing excitement from page to page. It is an interesting fact, surely, that this great wealth of detail, presented in such abundance, does not seem to lead to any clear conception of the main subject with which the book is concerned.

Is Sex Imaginary?

Professor Lillie, who has written a great deal on this subject of sex and who introduces this particular book with a splendidly written chapter, seems indeed to doubt whether there is such a thing as sex at all. He is led to wonder whether we are not simply dealing with a number of characters distributed in an alternative fashion, of purely incidental nature and not interrelated by a coherence of any general significance. It is the case that the philosophical basis of modern sex research has always been extraordinarily poor, and it can be said that the American workers have done more than the rest of us in destroying the faith in the existence of the very thing that we attempt to analyze. Nor has this great number of facts yielded any really new information relating to the more important problems of sex biology. For example, the problem of sex differentiation in relation to hormones remains just as great a puzzle as before. The lateral action of sex hormones remains still unexplained, save possibly in the case of the fowl's plumage where the brilliant suggestion of Lillie has given a clue to the understanding of such an intriguing phenomenon as lateral gynandromorphism.

But what is true of sex is true of the whole of biology, for this science has not yet reached that stage of its development when it can describe the objects of its searchings. The nature of the subject of scientific enquiry is commonly the last thing to be discovered. But if in a decade so much has been disclosed, what shall we not know after a century of intelligent and industrious work?

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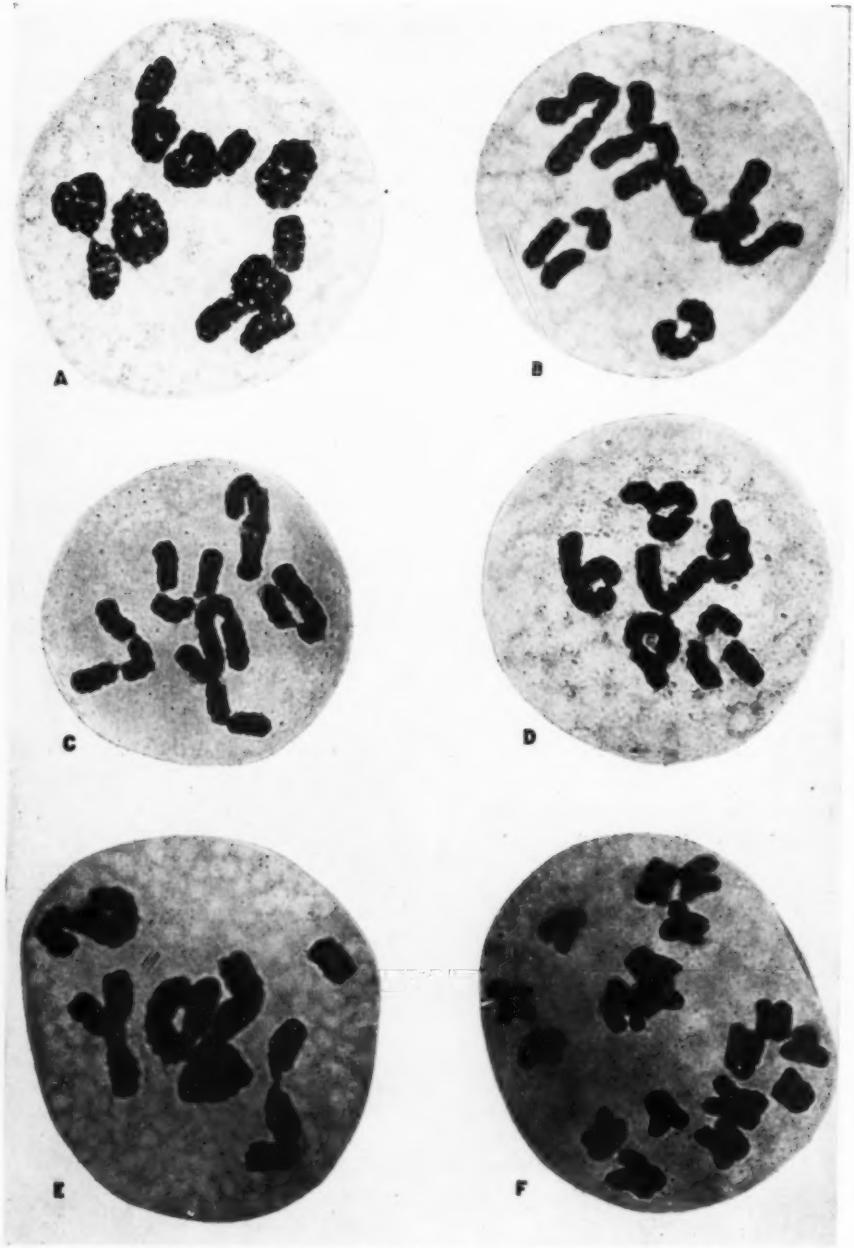
Mendelism and Chromosomes

LE LEGGI DI MENDEL E I CROMOSOMI, *by* Paolo Enriques. Pp. 224. 54 fig. Nicola Zanichelli, Bologna, 1932.

The scientific Academy of the Lincei proposed as a subject for a prize essay contest the relation between Mendelism and the chromosomes. This contribution from the late Dr. Enriques was awarded first prize. It attempts to give a systematization of the subject, laying down nine fundamental laws of heredity. There is a good bibliography.

Paul Popenoe.



CHROMOSOMES OF A TRIPLOID SPIDERWORT

Figure 11

Photographs of the first meiotic division of a triploid of *Tradescantia bracteata* from aceto-carmine smears which were heated and pressed. *A*, 4 ring-rod trivalents, 2 ring bivalents and 2 univalents; *B*, 4 U-chain trivalents, 2 ring bivalents one of which is interlocked with a trivalent, and two univalents; *C*, 4 U-chain trivalents, one J-chain trivalent with an interstitial chiasmata, and a straight-chain trivalent; *D*, 3 ring-rod trivalents, and 3 U-chain trivalents; *E*, 1 Y-trivalent showing a triple chiasma, 1 ring-rod trivalent, 2 straight chain trivalents, 1 U-chain trivalent, 1 ring-bivalent, and 1 univalent; *F*, a nine and nine distribution, with chromatids well defined.

CHROMOSOME BEHAVIOR IN A TRIPLOID TRADESCANTIA

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IN THE course of cytological investigation upon the Tradescantia cultures grown by Dr. Edgar Anderson at the Bussey Institution, a single triploid was found. The heterotypic division involved eighteen chromosomes which showed a marked tendency to form six trivalents as contrasted with the normal diploid of the species which has twelve somatic chromosomes and exhibits six bivalents at the heterotypic metaphase.

The plant was obtained from the botanical garden of Grinnell College, Iowa, but its original source is unknown. Diploid *T. bracteata* have been obtained from the geographical area which includes the states of Iowa, Missouri, Kansas, Nebraska and Arkansas. The tetraploid is unrepresented in the cultures. It may not exist in nature. Morphologically the triploid is indistinguishable from the diploid.

Triploids may be produced from a cross between a tetraploid which has *2n* or diploid gametes and a diploid which has *n* or haploid gametes. They also may arise from a union of a normal reduced haploid gamete with an unreduced diploid gamete. Non-reduction resulting from cold treatment has been observed by Belling[3] in Strizolobium and Datura. Presumably this triploid plant arose from the union of a normal *n* with an unreduced *2n* gamete.

The chromosomes of both the diploid and triploid *T. bracteata*, and the tetraploid species, *T. longifolia*, were studied for a comparison of chromosome configurations and for chiasma frequency at the first meiotic division. The study was made from aceto-carmine smear preparations.

In the diploid plants the bivalents usually take the form of rings with two terminal or subterminal chiasmata, although rod-shaped bivalents are also found, and occasionally three chiasmata may be observed in a single bivalent. Interstitial chiasmata were found frequently and constituted about 16 per cent of all chiasmata observed in the 100 pollen mother cells examined. The average chiasma frequency in the diploid was 2.0 per bivalent, or 1.0 per chromosome.

In the triploid the chromosomes were associated as trivalents in most cases although bivalents and univalents were found (Table II). Only 0.3 per cent of the chiasmata were interstitial. For comparison with the diploid the chiasma frequency in the triploid was based on the number of somatic chromosomes, and the average chiasma frequency per pollen mother cell was divided by 18. The chiasma frequency per chromosome was found to be .8.

The chromosomes of the tetraploid pair as bivalents or quadrivalents with about equal frequency. The paired chromosomes were associated by terminal chiasmata in all cases and no interstitial chiasmata were observed. The average chiasma frequency per chromosome was .9 in the tetraploid.

A comparison of chiasma frequency in diploid, triploid, and tetraploid Tradescantias is shown in Table I. In both triploids and tetraploids the chiasma frequency per chromosome is significantly less than it is in the diploid.

TABLE I.—Comparison between the diploid, triploid, and tetraploid Tradescantias.

	Somatic number of chromosomes per cell	*Mean number of chiasmata*	*Number of chiasmata per chromosome*
Diploid *T. bracteata*.....	12	12.1	1.0
Triploid *T. bracteata*....	18	14.4	.8
Tetraploid *T. longifolia*	24	21.4	.9

The types of trivalent configurations and their frequencies were as follows: The ring-rod type, 2.5 per cell (see Figure 11*A*); the U-chain type, 2.1 per cell (see Figure 11*C*); the J-chain type, 0.3 per cell (see Figure 11*C*); the straight chain type, 0.5 per cell (see Figure 11*C* and *E*); the Y-type, 0.2 per cell (see Figure 11*E*). The U-, J-, and straight-chain trivalents taken together as a class outnumber the ring-rod and Y trivalents, 2.9 to 2.7, respectively. Triple arcs are rare. Bivalents belong both to the ring and the rod types, 0.4 and 0.3 per cell, respectively. Univalents, 0.7 per cell, generally were removed from close association with their homologues.*

The triploid exhibited a large and variable amount of chromosome lagging at anaphase and telophase of the first meiotic division. These lagging chromosomes included both univalents and bivalents. Such chromosomes often failed to become incorporated in the daughter nuclei and form micronuclei. No microcytes were observed.

Late anaphase figures offered an opportunity to determine the distribution of the chromosomes. In 100 cells 59 showed from 1 to 3 lagging chromosomes. At this stage it was impossible to determine, in all cases, the exact number of chromosomes which fail to be included in the daughter nuclei. On the average one chromosome lagged so that it presumably failed to reach either pole. In only two daughter cells were there less than six chromosomes but nuclei with six or more chromosomes may be deficient for one of the chromosomes of the basic complement.†

In cells with no lagging chromosomes there was a marked tendency for nine chromosomes to pass to each pole, and the frequency distribution is not in accord with a random distribution of the six additional chromosomes of the triploid. Among the cells with lagging chromosomes the numbers approach a normal frequency distribution, although the modal frequency is eight, instead of nine, owing to the loss of about one chromosome at each pole.

The number of chromosomes which fail to become incorporated in the daughter nuclei at the end of the first meiotic division can be more accurately determined at telophase. A count‡ of the number of lagging chromosomes or micronuclei was made from 200 cells. Many of the micronuclei seemed to include bivalents, although at the earlier stages only univalents were lagging conspicuously.

‡TABLE IV.—Lagging chromosomes at telophase in the Tradescantia triploid

	Detached chromosomes					
	0	1	2	3	4	n
Number of diads.....	23	99	60	16	2	200

*TABLE II.—Types of configuration and chiasma frequencies found in a triploid Tradescantia

				Ring and rod	*U-chain*	*J-chain*	*straight chain*	*Y*	*Ring*	*Rod*		*Chiasmata*	*Interstitial chiasmata*
Cells	III	II	I	III	III	III	III	III	II	II	I		
100	537.0	62.0	65.0	247.0	205.0	28.0	45.0	19.0	37.0	25.0	65.0	1440	5
Average per cell	5.4	0.6	0.7	2.5	2.1	0.3	0.5	0.2	0.4	0.3	0.7	14.4	.05

Roman numerals III, II, and I represent trivalents, bivalents, and univalents, respectively.

†TABLE III.—Late anaphase chromosome distribution in the Tradescantia triploid.

	Number of chromosomes at poles								
	5	6	7	8	9	10	11	12	n
Number of poles**.....	..	..	3	13	50	13	3	..	82
Theoretical distribution	..	1	8	19	26	19	8	1	
Number of poles††.....	2	2	26	48	31	7	2	1	119
Theoretical distribution	..	2	11	27	37	27	11	2	

**Cells with no lagging chromosomes.
††Cells with one or more lagging chromosomes.

An average of 1.4 chromosomes fail to reach a pole and become incorporated in the daughter nucleus. Since some of these lagging chromosomes are bivalents nearly two of the 18 chromosomes of the triploid fail to be included in the two daughter nuclei.

Chromosome counts were also made at the metaphase of the microspore division of 51 cells. Microspores with nine chromosomes constituted the largest class and the distribution does not appear to be at random. There is a considerable deficiency of the higher and lower chromosome numbers. The distribution is similar to that found in the late anaphase distribution when all chromosomes reach the poles.* (Table V.)

Pollen sterility is characteristic of triploids. Pollen counts of the Tradescantia triploids were made on six different days. The percentage of good pollen found ranged from 28 to 65 per cent with an average of about 47 per cent. The percentage of morphologically good pollen is about 95 for the diploid and about 85 for the tetraploid Tradescantias.

Discussion

In triploids the extra haploid set of chromosomes tends to be distributed at random to the poles at meiosis. Such segregation has been shown in the triploid Petunia,[8] in a triploid Datura,[6] and is indicated in the sporophyte counts in triploid Hyacinthus.[3, 4] In the Tradescantia triploid studied by Darlington[7] there was an excess of microspores with nine chromosomes. Steere[12] found comparatively regular meiotic divisions in a triploid Petunia and the chromosome segregation was in accord with a random distribution of chromosomes.

In the triploid *T. bracteata,* the pollen mother cells with lagging chromosomes showed an approximately random distribution of the chromosomes, considering the decreased modal value caused by chromosome elimination. The cells with no lagging chromosomes at late anaphase showed an excess of regular divisions with nine chromosomes at each pole. The microspore counts also showed an excess of cells with nine chromosomes. Microspores with six or twelve chromosomes were not found, presumably due to the small size of the population and to the low frequency of these numbers at the meiotic telophase.

As a rule the microspores do not reach the division stage if one or more of the basic chromosome complement is absent. Pollen sterility is presumably caused by the absence of a complete haploid set of chromosomes. The microspore chromosome numbers show a distribution similar to that found at meiosis in the pollen mother cells with no lagging chromosomes. The chromosome deficiency which leads to pollen sterility apparently is caused by the lagging chromosomes. At late telophase an average of 1.4 chromosomes, some of which are bivalents, fail to be included in the daughter nuclei. About 90 per cent of the diads have detached chromosomes and the average number of chromosomes lost in these cells is nearly one per pole. If the single lost chromosome is the only homologue at the pole the microspore will be deficient and presumably sterile. If then the other two homologous chromosomes are distributed at random to opposite poles or to the same pole there should be considerable pollen sterility caused by chromosome lagging. The pollen sterility found in the Tradescantia triploid is variable, but the average is about 47 per cent. Apparently pollen sterility in the triploid is caused primarily by chromosome deficiency resulting from lagging at meiosis.

The chiasma frequency per chromosome is 1 in the diploid Tradescantia, .8 in the triploid, and .9 in the tetra-

*TABLE V.—The distribution of chromosome numbers in 51 microspore divisions.

	Chromosome number							
	6	7	8	9	10	11	12	n
No. microspores.....	..	2	8	33	8	0	0	51
Theo. distribution....	1	5	12	16	12	5	1	....

ploid. It has been assumed that the chromosomes in triploids are associated at pachytene in such a way that only two chromosomes are paired at any one locus.[10] Thus in the triploid the total pairing length of the chromosomes could not be greater than in the diploid, but the total number of chiasmata is greater in triploids than in diploids. Gairdner and Darlington[9] attribute the greater chiasma frequency per "potential bivalent" in the triploid Campanula to the greater chance of pairing of two chromosomes at all loci at pachytene. But in all normal diploids described, pairing of homologous chromosomes is complete at pachytene. Although there is an increase in total chiasma frequency in the triploid Tradescantia the number of interstitial chiasmata is greatly reduced as compared with the diploid.

The chiasma frequency in triploids is of interest in comparison with crossover frequencies in triploid Drosophila. In the triploids crossing over is less than in diploids, but is reduced especially at the distal ends of the chromosomes and increased in the region of the fiber attachment.[1, 11] In Tradescantia and Campanula the chiasma frequency per chromosome is reduced, and the chiasmata at metaphase are largely terminal. The decrease in interstitial chiasmata in the Tradescantia triploid would seem to indicate that the chiasmata are formed near the ends of the chromosomes or are terminalized more completely than in the diploid.

Summary

In the diploid *T. bracteata*, the chromosomes at reduction occur as ring and rod bivalents with a predominance of the former type. The average number of chiasmata per bivalent is 2.0 or 1 per chromosome. The pollen fertility is about 95 per cent.

In the triploid *T. bracteata*, varying numbers of univalents, bivalents, and trivalents are found. About half the cells contain all 18 chromosomes as 6 trivalents. All possible trivalent configurations occur where chiasma formation is terminal. These include the triple arc, the Y, the ring-rod, and the U- and J-chain. The number of chiasmata per chromosome is .8. Interstitial chiasmata are very rare as compared with the diploid. Pollen sterility is about 50 per cent. Chromosome distribution is not entirely at random and there seems to be a tendency for an equal number of chromosomes to pass to opposite poles. However, because of chromosome elimination due to lagging, a skewed curve of distribution results. Pollen sterility is probably due to chromosome deficiency.

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INHERITANCE OF WAXY ENDOSPERM IN SORGHUM

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SEVERAL investigators, shortly after the middle of the nineteenth century, noted starch grains which stain red with iodine, thus starting a chain of discoveries leading to numerous genetic studies pertaining to the character of the endosperm in certain grasses. The first investigator to report starch grains which stain red with iodine was C. Nageli, in 1858, who found such starch grains in *Chelidonium majus*. A. Gris[8] observed red staining starch in a variety of rice in 1860 and in 1885 Dafert[6] reported a similar observation in a variety of millet (*Panicum miliaceum*) from China.

Red staining starch in the endosperm of sorghum was found by Arthur Meyer[13] in 1886, who states that the sorghum grains which he used originated partly from Japan and partly from China. The Japanese grains he described as being enclosed, but not quite completely, in glossy brown glumes which were somewhat darker at the base and hairy at the base and apex. He states that in Japan this plant is known as Taka Kibi or Morakas (China). This last name indicates that the Japanese sorghum also originated in China. His Chinese grains resembled the Japanese exactly except that their glumes were black. Meyer designated this variety as *Sorghum vulgare nigrum glutinosum*. In addition to discovering the red staining reaction of the endosperm starch in sorghum Meyer made numerous other chemical tests in an effort to determine the nature of this type of starch and clearly recognized the analogy between the red staining sorghum and the glutinous type in rice.

This red staining reaction of endosperm starch has since been found in maize by Weatherwax[16] to be characteristic of the genetically distinct type of endosperm known as "waxy," a type originally obtained from China and described by Collins[4]. In 1921 Kempton[10] reported the occurrence of waxy seeds in two varieties of sorghums, one obtained from China and the other from the Philippine Islands. In the same paper he also described a number of varieties of *Coix lachryma jobi*, having waxy seeds. Thus this type of endosperm has now been found in five different genera of grasses, all of which are used for cereal purposes; namely, Oryza, Panicum, Sorghum, Zea, and Coix.

Although the waxy character in corn and the glutinous character in rice have been used in numerous genetic studies, no one seems to have undertaken to investigate the inheritance of this same character in sorghum, probably because, until recent years, most genetic studies with this crop have been confined to research looking toward improvement of the commonly grown varieties. With the discovery of the first case of linkage and the rapidly increasing number of seedling characters in sorghum[9], it became apparent that if endosperm characters could be found in sorghum it would greatly facilitate the prosecution of linkage studies and the ultimate mapping of the chromosomes of this species. Consequently, several attempts were made to secure seed of waxy endosperm sorghum and finally, in 1930, through the courtesy of Dr. L. D. Uichanco, Philippine College of Agriculture, the writer obtained a small quantity of a waxy endosperm sorghum grown on Talim Island, Lak of Bay, Laguna Province, P. I., and which is known locally as "Batad" (Tagalog). This sorghum is from the same locality from which one of the samples, *Andro-*

pogon sorghum negrosense, reported by Kempton, had been originally obtained.

Batad proved to be a late variety, barely maturing seed before frost. The stalk is slender, pithy, and tall, reaching ten to twelve feet in height, and bears eighteen to twenty leaves, having a yellow, not cloudy, midrib. The panicle is long and has five to seven nodes. The seeds are completely enclosed in long, glossy, red glumes; spikelets awned.

In external appearance seeds of the Philippine waxy sorghum are little different from the ordinary starchy varieties except the white waxy seeds are quite smooth in contour and have a dull, glossy seed coat. The endosperm texture is strikingly different from other sorghums, however, and when cross-sectioned presents a dull, glossy, or waxy, opaque surface, free from the crumbly starch grains encountered in the central area of the endosperm of other varieties, and lacking the hard, translucent area surrounding the soft starch region. When cut in two with a knife, ordinarily the waxy can be distinguished from the starchy seed because the cut is more easily made and the break is accompanied by a dull sound. This test, together with inspection of the fractured surface, is usually adequate to distinguish between the two classes of seed but distinction between waxy and non-waxy seed is clearly defined by the iodine test. When stained with an aqueous solution of potassium iodide and iodine, or of iodine, the cross-sectioned surface of the endosperm of waxy sorghum seed stains red, or reddish-brown, whereas, the non-waxy seeds give a typical blue starch reaction. Red staining starch of the waxy seed is confined to the endosperm; the pericarp and embryo staining blue.

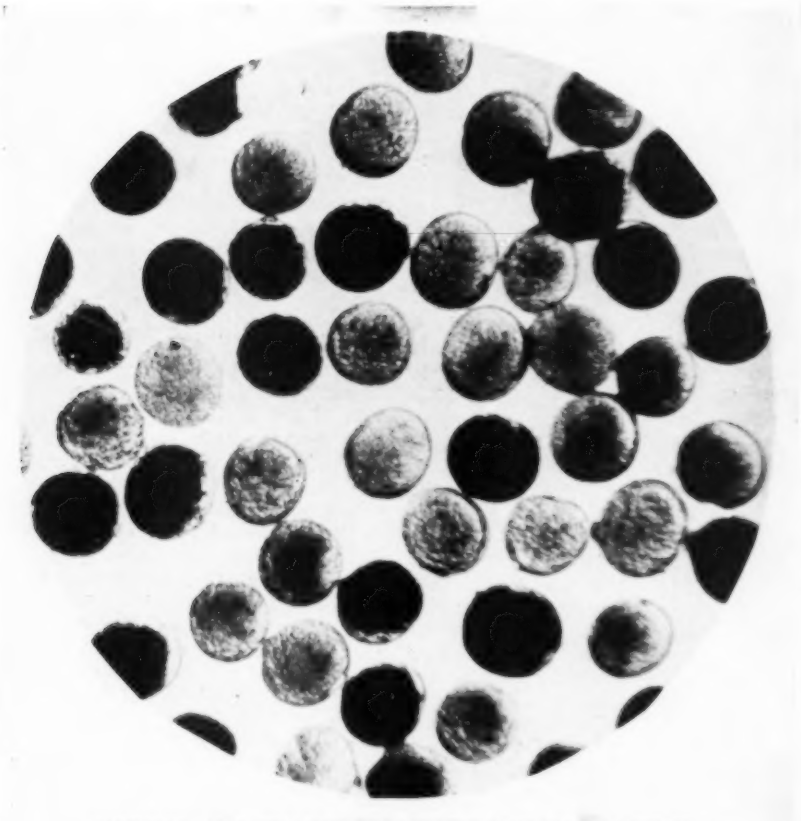
Xenia in Sorghum

Plants of the waxy type were reared in the greenhouse during the winter of 1930-31 and crosses made in both directions between waxy and milo and kafir, two common varieties having endosperm of the ordinary starchy type. Endosperm starch from F_1 seeds developed from emasculated waxy type flowers pollinated with non-waxy pollen exhibited a blue reaction with the iodine test. This expression of the immediate effect of pollen upon the character of the endosperm starch is a clear-cut case of xenia, the first observation of this phenomenon in sorghum. In this case xenia results only when pollen carrying the dominant, normal, starchy gene fertilizes an ovule carrying the recessive waxy gene and dominance of the starchy gene is apparently complete.

Segregation in the Pollen

The Mendelian theory of inheritance assumes random assortment and fertilization among the gametes. Although few Mendelian characters are visible in the gametoyphyte generation, Parnell[14] first demonstrated that in rice plants heterozygous for the glutinous character two types of pollen grains, one staining red when treated with iodine and the other blue, were produced in approximately equal numbers. Demerec[7] and Brink and MacGillivray[1] noted a similar differentiation and segregation between starchy and waxy pollen in heterozygous maize plants, and Longley[11] found the same iodine reaction among starchy and waxy pollen of Coix.

Pollen dimorphism is also easily demonstrable in sorghum. Pollen from the homoyzgous waxy parent (*wx wx*), when examined in an iodine solution, were found to display a reddish color while that from the starchy, or non-waxy parent (*Wx Wx*) stained blue. Plants heterozygous for the waxy gene (*Wx wx*), on the other hand, were found to bear both kinds of pollen grains, those in which the starch reserve stains red and those in which it stains blue, in about equal proportions. Figure 12 clearly shows the difference in reaction to the staining reagent by the two kinds of pollen and the segregation in a 1:1 ratio in the gametophyte generation of the F_1 hybrid. A sharper contrast between the two types of pollen can be gained by mounting the



NORMAL AND "WAXY" POLLEN GRAINS IN SORGHUM

Figure 12

Two kinds of starch have been found in several genera of cereals. The more common form is the ordinary starch which stains blue with iodine; the other is the "waxy" or "glutinous" starch, which stains red with iodine. In several genera the difference between these two starches is due to a genetic factor or gene—waxy starch being recessive to normal starch. These differences can be demonstrated in the pollen grains, which are shown here magnified 270 times. In sorghum plants heterozygous for the waxy gene half of the pollen grains stain blue (dark in the photo) and half red (light). It is a curious fact that in all the cereals studied the waxy starches have been found in Asiatic varieties. How this is to be accounted for is discussed in the text (Page 260).

pollen in iodine solution and allowing to stand. The starchy grains become darker blue while the waxy grains become a lighter yellowish color.

Counts of pollen grains from eight heterozygous plants (Table 1) gave quite close to the expected 1:1 ratio although there was a slight tendency toward a shortage of the starchy type. A shortage in this class can be accounted for by the fact that among almost any pollen mixture can be found some aborted grains empty of reserve material. Since the starch reserve is absent, the walls of such pollen grains remain unstained, are yellow in appearance, and some may be included along with the waxy pollen counts.

Inheritance of Waxy Endosperm

Waxy endosperm in sorghum behaves as a single recessive to starchy endosperm; however, since double fertilization takes place, flowers from a waxy plant fertilized by pollen from a starchy plant produce seed having a starchy endosperm. Due to the immediate effect of the pollen, therefore, the F_1 endosperm in such a cross is always starchy.

A total of 19 F_1 hybrids between the waxy type and the common starchy varieties (*wx wx* × *Wx Wx*), kafir and milo, was selfed. Plants were reared in the greenhouse and, while the heads were small and produced a comparatively small number of seeds, the total counts in the F_2 endosperm generation gave 1,393 starchy and 474 waxy seeds (Table II), a close fit to a 3:1 ratio. Two hundred and eight plants of the waxy-kafir cross were reared in the F_2 plant generation, 64 of which produced starchy seeds, 107 were heterozygous for starchy and waxy, and 37 were homozygous for waxy seeds. The significant shortage in the recessive waxy class can be accounted for by poorer germination or a higher mortality among the waxy seedlings, since it did not occur among the seeds. Determinations for the proportion of starchy and waxy seeds among a number of the F_2 heterozygous plants (F_3 endosperm) of the cross with milo gave a good 3:1 ratio and the grand total of all segregating heads showed 6258 starchy and 2030 waxy, or 24.5 per cent in the recessive class (Table II) though three heads out of the 16 classified deviated significantly from this ratio. Inheritance of the waxy gene in sorghum, as a simple Mendelian recessive, parallels the inheritance of a similar character in corn, first reported by Collins and Kempton[5], and also as found in rice by Kato (cited by Chang[3]), and also by later workers.

The fact that there is clear-cut segregation of endosperm characters among seeds from a single heterozygous plant indicates that the embryo sac in sorghum, as in maize, probably originates from only a single megaspore and that the other three cells of the tetrad abort and disintegrate. The processes of gametogenesis in sorghum have not yet been studied cytologically but as Anderson showed some years ago (see Weatherwax[15]), in the case of maize, the clear-cut Mendelian segregation of endosperm characters precludes the possibility that all four megaspores function in the production of the embryo sac.

Waxy Endosperm Confined to Orient

In addition to the waxy sorghum received from the Philippines an importation of five varieties of grain sorghum was later received from Dr. B. S. Kadam, Crop Botanist to the Government of Bombay, Karjat, India, among which, one variety, known as Red Dagadi, was found upon examination to be segregating for waxy endosperm. Stephens and Quinby* have recently examined a number of sorghum introductions, as well as some of the American grown varieties, and find waxy endosperm in Chinese Amber sorgo and some of the Kaoliangs, both of Chinese origin. A number of varieties of Amber sorgo, Leoti Red and Clubhead sorgo, and Schrock were also found to have waxy endosperm. At least some of these varieties are of hybrid origin and they conclude that the waxy type of endosperm probably traces back to Chinese Amber sorgo parents. Another variety of sorghum, Dwarf Java, imported some years ago from the island of Java, also has waxy endosperm. Crosses between this waxy variety and the one from the Philippines gave F_1 seeds having waxy endosperm, showing, as might be expected, that the same gene is responsible for this character in both of these varieties from East Indian islands.

It is apparent, then, that we now have waxy endosperm varieties of sorghum from China, India, Java, and the

* Unpublished. These observations are given with the kind consent of Mr. J. C. Stephens and Mr. J. R. Quinby, of the Chillicothe (Tex.) Field Station, who propose to publish these and other observations elsewhere.

Philippine Islands. Although the sorghums have been grown in America for many years, it is an interesting fact that waxy endosperm has not been found among the common varieties of this crop, probably because the bulk of our varieties are of African rather than Asiatic origin. Numerous sorghums have been introduced from India but they are usually large, rank, late maturing varieties not well adapted in their natural state to conditions in America. As waxy endosperm is discovered among other foreign introductions or in our American varieties, it would be very interesting and important to determine, if possible, whether such varieties had an Asiatic origin, either directly or indirectly, through hybridization.

It must be more than a coincidence that the general occurrence of waxy endosperm in sorghum, as well as in maize, rice, Coix, and millet, is confined to Asiatic regions. This situation is probably due to the fact that all of these cereals are used, some of them quite extensively, in the Orient for human consumption and the waxy, or glutinous, types are undoubtedly preferred for certain culinary purposes. It is a well known fact, for example, that the glutinous rice is universally used in China for various pastries and confections and it has been estimated that more than 20 per cent of the Chinese rice acreage is planted to this type. It is only to be expected, therefore, that a similar type of endosperm in the other cereals would be immediately recognized and propagated by natives familiar with this character. The occurrence of waxy varieties of maize in Asia is probably a good illustration of this process of development of cereals with waxy endosperms. Although maize has been known in Asia only since the discovery of America, waxy varieties have become established in China, Burma, and the Philippines, while in America, where maize has been grown for thousands of years, not a single waxy variety has been found. That the mutation to waxy endosperm does occur in America, however, has been shown by Mangelsdorf[12] who found waxy endosperm in North America in an old New England variety, and by Bregger[2] in a South American variety. In both cases the waxy endosperm proved to be genetically identical with the type originally obtained from China.

Summary

1. Waxy endosperm in sorghums stains red with iodine. It is inherited as a simple Mendelian recessive.

2. Xenia is displayed in the endosperm starch when recessive waxy flowers are pollinated with starchy pollen. The F_1 endosperm stains blue with iodine.

3. Segregation is visible in the gametophyte generation of heterozygous plants and red staining and blue staining pollen grains are produced in equal numbers.

TABLE I.—Pollen counts showing segregation of waxy and non-waxy in the gametophyte generation.

Plant No.	Pollen grains observed			Calculated 1:1 ratio	Difference and P.E.
	Blue	Red	Total		
2	320	336	656	328.0	8.0 ± 8.6
5	1515	1518	3033	1516.5	1.5 16.6
7	1504	1523	3027	1513.5	9.5 16.6
10	1618	1636	3254	1627.0	9.0 19.2
11	1609	1561	3170	1585.0	-24.0 19.0
13	1501	1555	3056	1528.0	27.0 18.6
18	1509	1525	3034	1517.0	8.0 18.6
19	447	461	908	454.0	7.0 10.2
Total	10023	10115	20138	10069.0	46.0 47.9

TABLE II.—Segregation for waxy seeds in the F_2 and F_3 (endosperm) generations.

	Plant No.	Non-waxy seeds	Waxy seeds	Per cent waxy	Deviation
F_1 Batad x Kafir:					
	1	115	38	24.8	- .2 ± 3.6
	2	115	30	20.7	- 8.2 3.5
	3	125	50	28.6	6.2 3.9
	5	59	28	32.2	6.2 2.7
	7	36	14	26.9	1.0 2.1
	10	66	21	23.6	- 1.3 2.6
	11	103	36	25.9	1.2 3.4
	12	75	25	25.0	0.0 2.9
	13	78	22	22.0	- 3.0 2.9
	14	130	49	26.2	2.2 4.0
	15	37	12	24.5	- .2 2.0
F_1 Batad x milo:					
	1	144	46	24.2	- 1.5 ± 4.0
	2	108	34	23.9	- 1.5 3.5
	3	110	38	24.4	- 1.0 3.7
	4	72	31	30.1	5.2 3.0
Totals		1393	474	25.4	7.3 18.6
F_2 Batad x milo:					
	5-7	313	101	24.4	- 2.5 ± 5.9
	9-7	243	83	25.5	1.5 5.3
	10-7	314	102	24.5	- 2.0 6.0
	11-7	232	68	22.7	- 7.0 5.1
	13-7	921	306	16.4	-74.2 9.8
	15-7	231	78	25.2	.7 5.1
	18-7	213	72	25.3	.7 4.9
	31-7	345	115	25.0	0.0 6.3
	32-7	304	96	24.0	- 4.0 5.8
	1-8	271	89	24.7	- 1.0 5.5
	2-8	317	107	25.2	1.0 6.0
	20-8	71	29	29.0	4.0 2.9
	1-11	376	152	29.0	21.0 6.7
	2-11	161	53	24.8	- .5 4.3
	3-11	335	69	22.7	- 7.0 5.1
	4-11	382	134	29.4	20.0 6.2
Grand total		6258	2030	24.5	-42.0 26.6

4. Clear-cut segregation in the endosperm generation of sorghum indicates that gametogenesis in this species is similar to that of maize.

5. The waxy type of endosperm in sorghum appears to be confined to varieties of Oriental origin, the same general region of the world where this same type of endosperm has been found in rice, millet, maize, and Coix.

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World Eugenics

EUGENIK UND WELTANSCHAUNG, *by* Bernhard Bavink, Hermann Muckermann, Karl Valentin Muller; *edited by* Gunther Just. Pp. 196. Berlin-München: Alfred Metzner Verlag, 1932.

THERE are here presented, in somewhat expanded form, three papers originally prepared for the Eugenics Society of Greifswald. The editor contributes a short introduction, apparently aimed mainly at the eugenically unsophisticated, with the purpose of dispelling popular misconceptions concerning Eugenics, and of indicating briefly what the Eugenics program is. Dr. Hermann Muckermann attempts to reconcile the attitude of Eugenics with that of Catholicism, discussing in particular certain aspects of the papal encyclical "Casti connubii," and Bernhard Bavink essays a similar task for Eugenics and Protestantism. K. V. Müller's chapter, Eugenics and Socialism, suggests a topic of more evident pertinence to contemporary problems, but the treatment is somewhat disappointing, chiefly because of the very general terms in which it is for the most part presented. The author points out the friction which, at least in Germany, has traditionally existed between the two movements, but cites recent writings which indicate that a rapprochement is in prospect. He emphasizes that Socialism (which term he uses in its broader sense) cannot succeed unless the dangers of biological degeneration are recognized and averted, and he discusses the biological significance of economic system would be more favorable to eugenic reform that a capitalistic system, is answered with a mild affirmative.

A list of literature cited is appended to each paper, with the exception of Muckermann's.

P. R. David.

A Glossary Of Genetic Terms

GENETICS has developed so rapidly that many terms in common use in genetic literature are not yet incorporated in the dictionaries. Many people who are interested in heredity are bothered by such words, for which no definition can conveniently be found. For this reason, it is proposed to publish occasionally a glossary of terms which would not be readily understood and which are not to be found except in new unabridged dictionaries. It is realized that these definitions will probably not meet with universal approval and comments and suggestions will be welcomed.

ALLELOMORPH—Mendelian characters are inherited in alternative pairs, or in alternative series. These alternative genes are called allelomorphs. Examples: Albinism (recessive), Normal pigmentation (dominant); Horns (recessive), Hornlessness (dominant).

CHIASMA—"In the diptolene stage (of cell division) the chromatids are associated in pairs in such a way that in one part of their length two chromatids are associated but in another part each is associated with a different chromatid. The point of exchange is termed a chiasma." (Sansome and Phipp, 1932.)

"Exchange of partners between the four chromatids of a bivalent." (L. H. Hill, 1932.)

CHROMATID—Chromosomes frequently bear the foreshadowing of a future longitudinal division so that they appear to be made up of two parallel threads. These threads are the chromatids.

CHROMOSOMES—Tiny dark-staining bodies visible in the nucleus of the cell at the time of cell-division. The number of chromosomes in any species is usually constant. The chromosomes carry the genes, linearly arranged, which control the development of Mendelian characters.

DIPLOID—Having two sets of chromosomes. Body-tissues of higher plants and animals are ordinarily diploid in chromosome constitution. See *Somatic*.

DOMINANT—A character possessed by one of the parents of a hybrid, which appears in the hybrid to the exclusion of the contrasted character from the other parent (the recessive). Thus in a cross of green- and yellow-seeded peas the first generation has yellow seeds. Yellow is dominant and green is recessive, being transmitted but not appearing in the presence of the factor for yellow.

FACTOR—Same as *Gene*.

F_1—(Pronounced eff-one). The first filial generation. The offspring of a given mating.

F_2—The second filial generation. Produced by intercrossing or self-fertilizing the F_1. The inbred grandchildren of a given mating.

GAMETE—A reproductive cell of either sex; e. g. sperm or ovum.

GENE—(1) The unit of inheritance, which is transmitted in the germ cells, and which by interaction with the genic and cytoplasmic complex controls the development of a character. The genes are arranged linearly in the chromosomes. (2) "The physical basis of heredity"—or more figuratively, the atom of the genetic molecule.

HAPLOID—Having the reduced number of chromosomes, as in germ cells, as distinguished from the diploid or double number of chromosomes in normal somatic cells.

HETEROZYGOUS—Containing both genes of an allelomorphic pair, or two genes of an allelomorphic series. Heterozygous individuals generally resemble the individuals homozygous for the dominant character, but they transmit the recessive to half their offspring.

HOMOZYGOUS—(1) An organism formed by like germ cells; (2) An organism is said to be homozygous for a given character when all the germ cells transmit identical genes for this character. This is the most frequently used meaning of the term.

MEIOSIS—The reduction divisions preceding the formation of gametes, in which the chromosome pairs separate, and the chromosome number is reduced to half the somatic number.

RECESSIVE—See *Dominant*.

SEGREGATION—Separation of allelomorphic genes at meiosis.

SELFED—Self-pollinated.

TRIPLOID—An organism characterized by having three times the reduced primary chromosome number.

THE MECHANISM
OF
CREATIVE EVOLUTION

By C. C. HURST

Doctor of Philosophy of the University of Cambridge
Author of *Experiments in Genetics*

From the Preface:

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